N. S. Vol. XII. No. 4. July, 1905.

The Psychological Review.

THE SYNTHETIC FACTOR IN TACTUAL SPACE PERCEPTION.

BY PROFESSOR THOMAS H. HAINES,
Psychological Laboratory of Ohio State University.

One of the dark regions of psychology, where there is an urgent call for more facts, is the process of tactual space perception. There is no reason to doubt that the 'local signs'—the peculiar qualitative marks of a pressure sensation at a given point on the tactual surface which distinguish it from other points and which remain the same for all pressure stimuli affecting the point, are of fundamental importance in this perception of locality on the touch surface. And it is equally certain, *a priori*, that there must be some means of definitely relating these — a framework in which they may be set, in order that they shall constitute a system and that there shall be a relation as of locality. In addition to this it seems reasonably well established that there are two sorts of synthetic factor for these local signs, the inner tactual sensations for the blind, as Heller has shown[1] and the visual image. Many persons with vision, when they try to touch a point which another has just touched, with their eyes closed, as by Weber's second method, find themselves referring the touch they just felt to a visual memory image of the part of the body in question. Some who have experimented and made careful introspections along this line seem to feel assured that this visual factor is the only synthetic factor in the case of any who have normal vision, that the visual image is so much superior to the tactual image afforded

[1] *Phil. Studien*, 12: 409.

Printed in Germany

by the inner tactual sensations that it always completely displaces it when present. I cannot cite an author who says this in so many words, but this is the feeling with which I come from a reading of a report as of Miss Washburn.[1] Wundt in his statement in the 'Outlines' is very much more conservative, as also Judd.[2] Wundt says (p. 118): "For many persons the visual images are pushed so far into the background that they cannot be perceived with any certainty even when examined with the greatest attention. The perception of space, in such cases, is perhaps an immediate function of tactual and motor sensations, as for the blind." This seems to me also highly probable. It is further possible that the motor, or better kinæsthetic sensations, are a factor in all tactual space perception, even in persons with a high degree of visual memory — that it plays a less and less conspicuous part as the visual factor grows in importance, but that there is a function of the kinæsthetic sensations in this organic complex which is not to be supplanted by the visual image. When one considers the fundamental importance of these sensations for the blind, and that we all have come through such a non-visual stage in our phylogenesis, it seems still more likely that these kinæsthetic sensations have a perhaps primitive, but none the less essential and by no means usurpable, function in the organization of our tactual space perception. It was with the hope of gathering some facts which would go toward establishing this position that this investigation was undertaken.

It is by no means a thorough canvass of the whole situation, but is rather of the nature of a preliminary report. The attack is made on the influence of the visual factor as shown by the better localization of points touched near prominent landmarks of the visual image, as, *e. g.*, the bounding lines. The relative importance of this factor is judged by the comparison which is afforded between results obtained by Weber's second method (1) with persons having normal vision, under natural conditions of attention with eyes closed, (2) with some of the same persons, with a special effort to recall and use a visual image of the body

[1] *Phil. Studien*, 11 : 2.
[2] *Phil. Studien*, 12 : 409.

surface in question, (3) with some blind observers, some of whom were congenitally blind and some had sight till three years old. Comparisons are afforded between (1) and (2), and between (1) and (3).

The method of the experiments was as follows : The observer was seated comfortably with the uncovered left forearm resting at ease, volar side up. The experimenter, with millimeter stick and fountain pen then marked eight points on each edge of the arm, the first on each side being on the most conspicuous carpal fold, and each successive one being at a two centimeter interval from the last. Points were marked by a mere touch of the pen. Eight points in the middle of the arm lying midway between these pairs thus marked were also used, making three at each level and twenty-four in all. These middle points were not marked, save in the case of three observers when a special effort at visualization was made, in order not to give the side points an undue advantage, visually, over the middle points by the introduced conditions. With some of the observers the last three toward the elbow, the last six, or the last nine were not experimented on. When ready to begin the experiment the observer sat with closed or averted eyes, and took in his right hand one of two similarly blunt pointed pencils (one millimeter in diameter) handed him by the experimenter. This he carried over to the right side of his body. The experimenter then touched with the other pencil any one of the twenty-four points, making a light but definitely visible indentation and allowing the pencil to rest there about one second. When he removed it the observer tried, as quickly as possible, to touch the same point. He was allowed to move the pencil after touching the arm, provided he should not lift it off the skin. When he halted, the experimenter took the pencil, and with dividers and measure observed the amount and direction of the error. These he recorded on a map of the arm surface, already prepared with the points marked. Thus he proceeded till all the points had been tested. The points were taken in any order, the only control observed, being to avoid stimulating a given point in close succession to a neighboring point, in order to avoid the confusing effect of after-images. Consider-

ing the number of points and the time required to make the record, we feel that the after-images played no part. The experimenter took the pencils together in his hand, and either one was given to the observer when ready for the next test. Only two observers, Ha. and Ru., were given two tests the same day. In most cases successive tests were separated by a week.

Sm., Age 20, F. Natural. Aver. of 7 Series.				Ru., Age 29, F. Natural. Aver. of 5 Series.			
R	*M*	*U*	Av.	*R*	*M*	*U*	Av.
4.6	4.9	5.0	*4.8*	4.1	9.1	5.5	*6.2*
7.8	7.6	5.1	*6.8*	7.8	7.9	8.1	*7.9*
8.1	10.2	8.1	*8.8*	6.5	7.4	7.5	*7.1*
14.6	13.4	8.1	*11.5*	8.2	5.7	10.0	*8.0*
13.4	10.0	9.3	*12.0*	8.3	10.9	8.2	*9.1*
16.2	10.8	7.7	*11.3*				
16.4	15.1	11.2	*12.8*				
12.8	10.3	11.2	*13.0*				
11.7	*10.3*	*8.2*		*7.0*	*8.2*	*7.8*	

Wi., Age 25, M. Natural. Aver. of 6 Series.				Wi. with Visualization. Aver. of 6 Series.			
R	*M*	*U*	Av.	*R*	*M*	*U*	Av.
9.7	7.4	4.3	*7.1*	6.8	5.4	4.5	*5.6*
8.7	7.9	6.9	*7.8*	9.6	8.5	4.7	*7.6*
7.0	7.3	5.3	*6.5*	7.9	5.1	6.6	*6.5*
5.5	10.0	9.0	*8.2*	4.8	7.6	9.6	*7.3*
10.2	11.4	10.1	*10.6*	8.8	6.5	6.6	*7.3*
8.8	14.4	9.8	*11.0*	7.0	6.3	7.0	*6.8*
7.7	17.7	13.8	*13.1*	9.1	8.4	9.1	*8.9*
9.1	8.9	23.2	*13.7*	5.0	5.5	11.2	*7.2*
8.3	*10.6*	*10.3*		*7.4*	*6.7*	*7.4*	

Ku., Age 19 M. Natural. Aver. of 4 Series.				Ku., with Visualization. Aver. of 4 Series.			
R	*M*	*U*	Av.	*R*	*M*	*U*	Av.
5.5	6.7	7.4	*6.5*	5.0	5.5	7.7	*6.1*
11.0	6.4	9.4	*9.0*	7.0	8.2	8.6	*7.9*
10.1	14.1	7.2	*10.5*	6.4	8.0	10.2	*8.2*
11.5	11.2	11.2	*11.3*	9.5	8.9	17.6	*12.0*
7.9	12.7	3.6	*8.1*	9.0	9.2	11.7	*10.0*
15.0	16.2	14.5	*15.2*	12.9	9.4	14.1	*12.1*
9.9	10.9	11.4	*10.7*	11.0	8.1	16.2	*11.8*
12.9	19.9	15.2	*16.0*	16.0	12.2	11.2	*13.1*
10.8	*13.3*	*10.0*		*9.6*	*8.7*	*12.2*	

Pa., Age 19, M. Natural. Aver. of 2 Series.

R	*M*	*U*	Av.
9.5	2.7	3.0	*5.1*
6.5	6.7	2.5	*5.2*
13.5	8.5	7.0	*9.6*
9.0	9.5	10.5	*9.6*
2.0	17.5	9.5	*9.6*
16.5	13.0	8.5	*12.6*
5.2	8.5	16.5	*10.1*
11.0	12.5	16.2	*13.2*
9.1	*9.9*	*9.2*	

Pa. Eyes on arm till touched. Aver. of 2 Series.

R	*M*	*U*	Av.
3.5	2.0	2.0	*2.5*
6.2	6.5	3.0	*5.2*
5.0	14.0	7.0	*8.6*
5.0	6.2	7.7	*6.3*
8.0	4.5	15.5	*9.3*
17.7	8.0	8.0	*11.2*
10.7	10.0	11.5	*10.7*
11.0	6.5	11.5	*9.7*
8.4	*7.2*	*8.3*	

Ha., Age 31, M. Natural. Aver. of 6 Series.

R	*M*	*U*	Av.
8.6	8.1	4.0	*6.9*
5.4	5.3	9.5	*6.7*
10.4	11.5	6.9	*9.6*
7.2	11.1	11.2	*9.8*
9.9	10.9	12.6	*11.1*
8.6	5.7	18.6	*7.6*
11.1	11.7	12.1	*11.6*
16.5	10.5	9.4	*12.1*
9.7	*9.3*	*9.3*	

Mi., Age 16, F. Blind since 2d Week. Aver. of 5 Series.

R	*M*	*U*	Av.
4.7	2.9	3.8	*3.8*
8.0	8.3	5.8	*7.4*
6.6	6.2	9.4	*7.4*
4.8	6.5	6.7	*6.0*
3.4	6.8	6.0	*5.4*
5.6	5.4	4.6	*5.2*
7.0	6.9	5.1	*6.3*
5.7	*6.1*	*5.9*	

Gf., Age 15, F. Blind since 18th Month. Aver. of 4 series.

R	*M*	*U*	Av.
8.6	10.5	5.5	*8.2*
11.7	10.0	10.1	*10.6*
8.2	9.0	9.1	*8.8*
7.7	12.6	11.0	*10.4*
9.5	5.5	12.2	*9.1*
7.2	7.5	9.2	*8.0*
6.7	16.5	8.5	*10.6*
7.2	9.4	17.4	*11.3*
8.3	*10.1*	*10.4*	

Ta., Age 14, F. Blind since 3d Year. Aver. of 6 series.

R	*M*	*U*	Av.
4.3	3.7	6.7	*4.9*
6.3	4.7	6.5	*5.8*
8.7	5.8	8.5	*7.7*
5.7	8.2	9.1	*7.7*
9.2	12.7	7.9	*9.9*
6.2	6.7	10.8	*7.9*
9.2	10.8	11.2	*10.4*
14.7	15.0	14.9	*14.9*
8.0	*8.4*	*9.8*	

Bu., Age 14, F. Blind since 5th Day. Aver. of 6 Series.

R	*M*	*U*	Av.
6.6	6.4	8.4	*7.1*
6.1	8.0	8.8	*7.6*
9.3	10.3	11.6	*10.4*
7.9	11.6	14.1	*11.2*
17.1	17.3	10.9	*15.1*
11.0	14.1	13.2	*12.8*
9.6	11.3	11.2	*10.7*
14.6	10.3	20.3	*15.1*
10.3	*11.2*	*12.3*	

Ev., Age 15, F. Blind since 3d Day. Aver. of 6 Series.

R	*M*	*U*	Av.
7.7	9.2	7.7	*8.2*
7.3	4.8	8.2	*6.8*
7.9	9.7	9.2	*8.9*
5.0	10.0	14.6	*9.9*
12.3	8.6	10.5	*10.5*
11.7	8.7	15.5	*12.0*
9.9	19.8	20.7	*16.8*
11.9	14.2	23.7	*16.6*
9.2	*10.6*	*13.8*	

Co., Age 13, F. Congenitally Blind. Aver. of 6 Series.				Gu., Age 9, M. Blind since 3d Year. Aver. of 6 Series.			
R	*M*	*U*	Av.	*R*	*M*	*U*	Av.
6.7	6.7	7.4	*6.9*	4.1	5.2	7.1	*5.5*
9.3	6.5	10.0	*8.6*	6.5	7.5	7.3	*7.1*
10.7	5.9	6.3	*7.6*	7.5	7.6	13.0	*9.4*
8.7	7.5	6.9	*7.8*	8.1	6.6	10.3	*8.3*
8.7	7.1	11.1	*9.0*	9.2	7.2	14.3	*10.2*
9.4	10.0	11.1	*10.2*	11.2	8.2	15.5	*11.6*
				7.5	8.3	14.1	*10.0*
8.9	*7.3*	*8.7*		*7.7*	*7.2*	*11.7*	

The averages of errors in the tables are arranged just as the points lie on the left arm of the reader when he lays his arm down on the table volar side up. The wrist points are at the top of the table, the radial points to the left, and the ulnal to the right. The number, in each case, is the average, in millimeters, of the errors for the point in question, for the number of experiments given at the top of the table. For instance, in the first table are the average errors of Sm. She was tested seven times on the twenty-four points. The average of the seven errors on the radial point on the carpal fold is 4.6 mm. and the average of seven errors on the ulnal point eight centimeters above the carpal fold is 9.3 mm. These average errors are then further averaged for each of the eight levels at the right side of the table, and for the *R*, *M* and *U* eights at the bottom of the table. Of course the points were not precisely the same in different experiments on the same person, as will be seen from the above description of method. This could have been secured by permanently marking the points. But it was deemed better to avoid such a definite fixing of the visual attention on the experiment. It would at once have introduced an artificial element of considerable importance. As it is, this method is a better means of affording a basis for comparison of errors, vertically and transversely than is the method of areas as used by Pillsbury.[1] The points, considered the same in averaging these results of successive experiments, will all fall in a circle five millimeters in diameter. The purpose of the experiment was not discussed with the observers until after the

[1] *Amer. Journal of Psy.*, 7: 42.

experiments. They were asked where they could localize with most assurance, and by what means they did touch the place. Looking now at the general averages for the *R*, *M* and *U* points in the six observers with normal vision and under natural conditions of attention, for the influence of the visual factor as shown by the larger average error for the *M* points than for the side points, we find larger errors in the middle for four, Kn., Pa., Wi., and Ru. The excess error for *M* over the largest side error, in the case of Kn., 1.5 mm. is perhaps significant. He is a good visualizer. The next best, Pa., with an excess of only 0.7 mm, is by a poor visualizer. Pa. says he never had a visual image of his arm. Ru, with an excess of only 0.4 mm, had no recognizable visual image. The next, Wi., is a good visualizer, but he shows only a small excess of 0.3 mm. Ha. and Sm. are both pretty good visualizers, but had no recognizable visual images. They both give the largest average errors on the *R* side. In this comparison then we have no positive evidence for the influence of the visual factor as making for better localization on the side points. Poorer visualizing faculty is by no means paralleled by decreasing excess of average error in the *M* points. Two fair visualizers give a better average error for *M* than for *R*, and one who seems to have a minimum of visualizing power gives the next to the largest excess for *M* points.

But it may be urged that even in the case of the good visualizers, the visual factor was not called into play, as the artificial character of the experiment set at once a specific touch problem. I do not think this is true, but to set at rest any such objection, and also to see if more evidence of the visual factor could be obtained, I tried Wi., Kn. and Pa. for a number of series each, with a special direction of the attention to the visual image. As Pa. had no recognized visual image, I had him look at his arm while I touched it, and then close his eyes and try to touch the same point. In these cases, as mentioned above, the middle points were marked, as otherwise the side points would have been given just this much more visual emphasis. It is rather significant that each one of these three observers, under these conditions which have been

made especially favorable for more accurate localization on the sides if the visual factor aids in this, gives a smaller average error in the middle than on either side. It cannot be said that this is due to the marking of the middle points, else the marking of the side points and not the middle, in the previous experiments, should have yielded a more significant average error for the middle, for Wi. and Pa. It must be observed, though, that the average error is, in every case smaller, save only the *U* series for Kn. This may possibly be due in some small part to training. But it is difficult to see how practice could manifest such an effect in only four series altogether as there are for Pa. It would seem as though the visual factor thus introduced must be almost entirely responsible for this decrease of the average error. But then the pertinent question remains unanswered, Why do not the regular alignments of the visual image — the side boundaries of the forearm, of which there has been so much more experience and which are more significant altogether than these ink dots — why do these not secure better localization on the side parts? If the better localization on the side parts in these observers, under natural conditions of attention, were due, as was supposed, to the influence of the visual factor, then emphasizing this factor ought to make for a relatively better side localization. Such expectations are reversed. This means either of two things: the visual factor is not prepotent here, or it does not have the effect of influencing for better localization on the sides. Evidently it is a factor; the decreased errors show this. But it is not the important element in localizing on the boundaries of the visual image which some investigators have claimed it to be. Localization on the side of the wrist is better, owing to the peculiar nature of the tactual surface. Bones and tendons are the factors which make for more accurate touch on these parts.

The showing for the part of the visual factor in tactual localization, as given by the larger error in the middle of the forearm, being of such an equivocal character in these normal observers, I was interested to see whether the blind would not give about as significant evidence for a visual factor (?). If the larger errors in the middle are not due to the visual factor, but

are due to accident — a complexity of causes as yet unanalyzed, then the blind might give larger errors in the middle. At the least if we could get results from them similar to those already obtained from observers with normal vision, in respect to the larger errors in the middle of the arm, we should certainly then be able to dismiss the theory that this larger middle error was due to the visual factor. By the courtesy of the Superintendents of the Ohio State School for the Blind, Mr. and Mrs. Smead, I was enabled to experiment on seven pupils in this school. Only one of these was congenitally blind; three lost their sight during the first two weeks of life, and are for this experiment as good as the congenitally blind; one had sight till a year and a half old; and two saw till three years old. They were all experimented upon in the same way as the other observers in the first experiments under *natural* conditions of attention.

We find one of the four, who may surely be considered to have no possibility of a visual factor in tactual localization, Mi., gives the largest average error in the middle, and, when one considers the smallness of the error, it is relatively as much of an excess error in the middle as in any of the normal observers excepting Kn. But this is only one case out of seven, as against four out of six in the seeing observers. Mi. was however, without doubt, the most careful of the blind observers, and the fact, that she gives this larger middle average error, casts serious doubt upon this being due, in observers with normal vision, to the visual image of the part touched.

The general error of the blind decreases from the ulnal (inside) to the radial (outside) of the arm. This progressive increase of the averages as one reads from the *R*, through *M* to *U*, is found in the tables of results presented for Gr., Ta., Bu. and Ev. Greater average error for *U* than for *R* are also seen for Mi. and Gn. Co., the only one who was literally a congenitally blind, gives a very slight excess for *R*. She was not the intellectual peer of any one of the other children. She was more than a year behind the girls of fourteen, though herself thirteen. It should be stated, also, that Gn. was an exceedingly nervous child and that the experiments, as conducted,

were too much of a strain on him to show his best results. He came on with his pencil very quickly after the touch was given, and moved it very little after touching the skin. He said that it got away from him very quickly. This is evidence of a pretty simple dependence upon the touch alone. The whole procedure with him was very like that of a child making his first efforts at penmanship. He lacked finer coördinations, — could not proceed carefully to find the point after touching. Probably, for his degree of attention, the former touch sensation completely vanished when he himself touched his skin. On account of these exceptions, we may say that this progressively larger error toward the ulnal side seems to be characteristic of the blind. There is no such general tendency among the observers with normal vision, nor the counter tendency. Sm. and Ha., the two observers who do not give the largest average error in the middle, do give the reverse, the largest on the *R* side. And with their largest errors in the middle, Kn. tends as these, and Ru. and Wi. tend as the blind.

In regard to the average errors of the different levels, there is no significant difference between the blind and those with normal vision. All show a tendency to best localization on the wrist and progressively larger errors toward the elbow. There are some noticeable exceptions to this, though, in the averages lower than that of the wrist points, for points up to two or four centimeters, as for Wi. (natural) and Ev., in a second low error midway, as at the fifth level in Kn., and in the descent toward the elbow, as in Mi., and in Wi. with vizualization. There is also a tendency to lower the errors on wrist and toward elbow with vizualization. This is the only feature in connection with this comparison of vertical level averages which indicates the functioning of the visual factor, and it is not general. On the whole, there is more difference between the error on the wrist points and those two centimeters above, than between any other levels. This, however, is not due to the better visual image of the wrist, because it is more generally exposed to view. The closer adherence of the skin and the very much more definite local signature which is made possible by the bones and tendons afford an adequate basis for this.

And, on the whole, the blind have it as well as those who see. In fact the progressive increase of error toward the elbow and the exceptions just noted seem, alike, to be more likely to be explained by a reference to general tendencies in the moving member which is doing the localizing, than by reference to the visual factor.

The facts with regard to the *direction* of the errors of localization are difficult to summarize. General tendencies can be made out from the record-maps for the observers, in the order of the above tables of amounts of error, as follows:

Sm.	Great majority of errors *P* (peripheral, or toward the wrist).	Both sides tend in, *i. e.*, error is *U* for radial and *R* for ulnal points.
Wi.	Excess of errors *P*, save in the peripheral-radial third of the field, where it is *C*.	No excess. Both tendencies in all parts.
Ru.	Slight excess of *C*.	Excess of *U*.
Kn.	*C* in central half. *P* in peripheral third.	*R* on ulnal. *U* on radial.
Ha.	*C* except some ulnal points.	*R* on middle and radial. *U* on some ulnal.
Pa.	Almost universal *P*.	Very slight *R* tendency at side points.
Mi.	General tendency to *C*.	Very slight *R* on ulnal and *U* on radial.
Gf.	*C* in excess especially in the peripheral-radial half.	*R* especially in peripheral-radial half.
Ta.	Slight excess of *P* first, then *C* later.	*R* throughout.
Bu.	*P* throughout.	*R* especially on ulnal side.
Ev.	*P* throughout.	*U* on radial and middle; *R* on ulnal.
Co.	Tendency to *P* in central and *C* in peripheral.	*R* throughout, especially clear on ulnal.
Gn.	*P* throughout.	*R* throughout.

The most considerable factor in the majority of the errors was lengthwise of the arm, *P* or *C*. An error of 11 mm. *CR*, for example, would probably be about 10 mm. *C* and 2 mm. *R*. But the analysis afforded in this statement seems to be sufficient for the purposes here in view. It is at once seen that the observers with normal vision, manifest very diverse tendencies, both in the longitudinal and the lateral or transverse errors. Two show an excess of *P*, two of *C*, and the other two *C* on one part and *P* on the other part of the map. This is by no means the general tendency to *P* errors which Pillsbury found. The same observers in side direction of errors give one *R*, one *U*, two *R* on ulnal and *U* on radial, and two no marked side tendency. The lack of general tendency accords in so far with the records of the *amount* of error of these same observers. Of the seven blind observers, there are four *P*, two mixed, and one *C*. And for the transverse error there is yet more accord. All give an excess of *R* errors on the ulnal side. Five of the seven give the same throughout, one giving especially marked *R* errors on the radial side. The other two give *U* errors on the radial side. This marked tendency to *R* errors in these observers seems as though coördinated with the above mentioned tendency which they showed to a progressively better localization on the radial side. Three of these observers show both tendencies. May they not be assumed, provisionally, to be characteristics of the tactual localization reaction in the blind?

This better localization on the radial side can be attributed only to (1) the local signature of this side being more nicely differentiated, or (2) to the inner tactual sensations of the joints of the localizing member, or both. The anatomical structure of the forearm undoubtedly affords a better local signature for the radial side of the volar surface than for the middle or ulnal side. Then too there is basis for better local signature in the natural functioning of the arm. The radial is the front part of the arm. It is naturally carried forward. The forward position is the middle point of the arc of its rotation. There is thus more experience of touch on this side, and experience is a recognized factor in the perfection of local signature. By experience is

here meant not only individual experience but the larger race training. But this perfection of the local signature through experience already involves, as a part of its machinery, the second factor above alluded to as a possible ground of explanation of the smaller errors on the radial side, namely, the inner tactual sensations in the touching member. Tactual space, in the sense of perception of location upon the body surface, comes very largely through the touching of the body by its own moving parts; so that local signature cannot be considered a thing apart from the so-called synthetic tactual factor, except for artificial purposes of analysis. In nature it grows along with the inner local signature of this synthetic factor. But, to return to this second factor as a ground of explanation, of the more accurate localization on the radial side, it seems that the radial side, both in experience in general as above alluded to, and in this special experiment on the volar surface, gets an emphasis as a *line of reference*. The other points are gauged as so far from the corresponding radial point. The inner tactual sensation of tension, which arises when the right arm has touched the radial point of the other arm, may come to pose as the limiting or measuring sensation. This seems plausible, especially from the functional preëminence of the radial part. It is also the only likely ground of explanation I have been able to discover for the predominance of *R* errors in these blind observers who at the same time give their least errors on the radial side. Errors on the other parts are larger and at the same time tend toward this as a line of reference. It emphasizes especially the tensions in the shoulder. If this is true the same should be worked out for the elbow in regard to the *P* and *C* errors. Our results furnish only the suggestion of this possibility in the above mentioned exceptions to the regular increase of error toward the elbow. Wi., in one record, gives the following averages from the wrist up, 8.0, 6.0, 4.3, 7.5, 4.8, 6.6, 5.6 and 4.3. There is a change in the direction of the error at the fourth row. Fourth tends *C* and third tends *P*. So also at the eighth is a tendency to change to *P* again. The carpal points all tend to *C*. From the wrist up these tendencies are successively *C*, *P*, *C*, *P*. It looks like two points of best local-

ization — points of reference as we have called the radial side. Wi. said in this case that the points of the third row (4.3) were the easiest. He often said the points toward the elbow were easy, though he often had an illusion of these being nearer the elbow than they were in fact. Both of these questions should be made the subject of careful investigation with most skillful introspection.

When asked how he proceeded in trying to touch the same point, Kn. said: "It is hard to know where to go if you do not 'strike' at the first trip, especially on the large part of the arm." This indicates a place of service of the visual image. But the visual image is not there to do the work. Of course it is there and functions even when introspection cannot find it. But it cannot give as accurate results as the synthetic tactual factor. Wi. says: 'I have a good visual picture, but localization is not definite in visual terms.' He clearly feels that there is another sort of synthetic factor functioning, though I did not discuss this with him. Ru. says: "I remember the way the place feels. The quickness and accuracy with which I can place the pencil on the arm after the stimulus is given, determines the accuracy of the localization." Ta. (blind) says: 'I am perfectly sure where the spots are, but I can't find them.' And again, 'I know right where you touch me, but I don't know where my arm is.' This calls attention to the inner tactual sensations of the touched member being of importance, as well as those of the touching member. It also indicates the function which the visual image *could* fulfil in her case. It would form the larger framework in which the smaller and vaguer tactual image would find its setting. But the remarks of Wi. and Ru., above, indicate, to my mind, the great importance of this more primitive and vaguer factor; the tactual image is perhaps too dignified a name for it, but it is the immediate framework into which these local signs are set. It is by their places in this that they are signs of locality. I feel that this is the case from my own introspections during this experiment. I can feel where the touch is in a vague way without any visual image, and I cannot feel where it is with a visual image but independent of this which I have called the tactual synthetic factor.

We have evidence of this being used by the other observers with normal vision; and we see that the blind tend to a greater precision (by its exclusive use) on the radial side, whereas the normals (with the visual factor) tend to spread their errors more evenly. The observers with normal vision also show a greater complexity of interworking factors, as would be expected. Greater variety of type of reaction is afforded. This present study has not contributed much to our knowledge of the interworking of these various factors concerned in our tactual space perception. I hope, though, it has, in a measure, restored the synthetic tactual factor to its place, and also called attention to the very rich field that lies here for further investigation both in tactual space perception and in individual psychology.[1]

[1] The MS. of this article was received December 20, 1904.—ED.

CONSCIOUSNESS AND ITS OBJECT.

BY FELIX ARNOLD,
New York.

What was considered *selbstverständlich* in previous treatises on psychology, and what even now is set down as something not to be disputed, is that consciousness in subject to immediate awareness; that an immediate intuition of consciousness is possible; and with this as a basis an attempt is made to prove the unity of mind, the falsity of 'atomistic' psychology, or what not, while in philosophy, it is taken at times as a convenient bridge across to reality, some trying even to build up an external world out of consciousness. Now whether or not philosophy depends upon psychology is not here the question, but if philosophy uses among its concepts that of 'consciousness' it must at least take into consideration the knowledge of consciousness as far as psychology is able to give it to us. The trouble with most present philosophy is that it lags behind about fifty years after modern psychology, at the same time declaring with a somewhat lordly air, the complete separation of philosophy and psychology. I think it advisable to examine how far it is possible to have a direct awareness of consciousness, what we mean by a mental state, and to draw therefrom a formula with which we can work in treating of object, consciousness or reality.

I.

The notion that direct awareness of a mental state, of consciousness is possible, arises partially I think, from a confused idea of the possibilities of introspection and introspective analysis. Is it possible to view a mental state as past, or when it is present? Can we hold it up and look at it during its existence, or are we able to examine it as a past mental state? Is it possible for us to be aware of a mental state directly, when such state is consciousness of something else, *e. g.*, an object in the

external world; or of a mental state which is past? The former, *i. e.*, Can we view consciousness as such, directly and immediately, involves the problem of will, self-activity and the self, later to be discussed. The latter inquiry, *i. e.*, Can we view a mental state as past, concerns the problem of introspection and all that it implies.

What is it that we are conscious of in introspection? Of what does consciousness of a past mental state consist?[1] When we say that we are conscious of a past mental state, obviously the past mental state is not the state present. It may seem proper to rest satisfied with saying that we introspectively observe consciousness, and not to go further and inquire what it is which in reality is observed. By saying that we are conscious of a former mental state we tend to delude ourselves with the belief that we have a direct awareness of consciousness. Now the object of introspection is the past mental state. But a past mental state is no mental state; it is a myth; a past mental state has no existence; it has gone forever. In introspection we are not conscious of the consciousness of some object; for that is what is sometimes actually assumed in the expression 'introspection of psychic life.' We cannot be aware of the state as present, for it is past; and as a past state it does not exist; it is not a mental state at all. What we are aware of must therefore be something not mental, *i. e.*, something not wholly psychic, but simply some object as in the case of immediate perception. In introspection I may be conscious of some object to which I take the attitude as past; but I am not aware of a mental state in the past. Consciousness of the past is not past consciousness, and inner and outer perception are both alike, both are occupied with a present object, whatever our attitude be in the matter.[2]

Leaving aside for the moment the question of a self aware of the passing states, a possible objection to the view just presented, is that moments of consciousness are not time moments,

[1] Cf. on this point, Wundt, 'Selbstbeobachtung und innere Wahrnehmung,' *Phil. Stud.*, IV., 1887; James, *Princ.*, 1890, ch. VII., and Stout, *Anal. Psy.*, 1896, Int.

[2] Cf. Münsterberg, *Grundzüge*, I., 1900, II., ch. 7, §3; and Wundt, *Grundzüge*, III., 1903, ch. 15.

but persisting; that instead of a mathematical point of time we may have a 'duration block' of consciousness and as such may become aware of it. "The moments in the schema of time may go on flowing, but the present moment of consciousness may still remain unchanged; nay, it is even conceivable that a present moment of consciousness should fill a whole eternity. The radical difference of these two moments is well illustrated in the popular story of the monk who happened to listen to the song of a bird from paradise for but a single moment and found that meanwhile a thousand years had passed away. The present moment of consciousness does not change with the change of the present time moment; the two are totally different in their nature. Now the moment of consciousness not being a time moment, not being a continual flux as the latter is, may include as well its own consciousness, and thus be a moment of self-consciousness; and as a matter of fact a present moment of self-consciousness does include the knowledge of the present moment of consciousness within the self same present moment."[1]

The argument here presented implies either a self, conscious of its own activity, or the power of introspection to observe a past mental state, the power of consciousness to turn around and take a look at itself as it were, before it vanishes into the past. As concerned at present, I shall examine only whether the difference between the moments of time and moments of consciousness makes any difference in the results thus far obtainnd, that, leaving aside for the present the question of a self aware of its own activity, consciousness must have an object in the present, whether the moments be short or long.

Consciousness at any moment in its persistence, say at its beginning, must be occupied by some object in the present. If we have consciousness of that object, its continuance will not change it into self-consciousness nor allow it to become self-consciousness. The fact of its persistence makes no difference. If another state arise, we do not have consciousness of the consciousness of the object, plus consciousness of the object alone; for the first state must pass away to be succeeded by the following. We may have consciousness of the state as past, plus

[1] Sidis, *Psychology of Suggestion*, 1899, pp. 195–197.

the present object; but this is not self-consciousness. It is simply consciousness of two objects.

If the present moment of consciousness fill eternity we have merely eternal continuance of the consciousness of some object always present. The monk in the story heard simply one long sweet song; of this aware. Had not some other object presented itself, he probably would be hearing it still. If we take the last instant in which the consciousness of the object exists, we have at that moment a moment of consciousness coincident with the time moment, and conditions are then the same as if there were no difference between moments of consciousness and time moments. During the moment of consciousness present, we cannot have another moment of consciousness arising and aware of the first moment. What may take place is an addition to the first object cognized; we would then have a consciousness of two objects, (1) the present object; (2) the past mental state, *i. e.*, no mental state at all, but another object. We would not have consciousness of (1) the object, and (2) the consciousness of this object. Such states would have to be separate moments; they could not be included in the one moment without the implication of an active self. And for such view it makes no difference whether or not conscious moments and time moments are the same or different. If the fallacy does not consist in that of introspection, *i. e.*, awareness of past mental states, then it consists in the supposition of a self aware of its own activity.

In examining therefore whether or not we have a *Selbstthätigkeitsgefühl* or a consciousness feeling its own stream, some misunderstanding arises from a confusion of the facts of be considered with those which are not. The question is not whether or not there is such a thing as self-activity, conation, will or what not; but whether we can be immediately aware of this activity as such. No attempt is made to reduce this activity to body sensations or association complexes. Let the activity be what it will. The point at issue is: Of what are we conscious in moments of activity; what is the content of consciousness in moments of mental exertion other than the so-called cognitive or emotional elements.[1]

[1] See Stout, *Anal. Psych.*, 1896, I., p. 163.

Against the hypothesis that we have a feeling of mental activity *per se*, the 'infinite regress' argument will scarcely hold. As usually given it runs as follows: Consciousness of mental activity would necessitate a double process going on, (1) consciousness of the object, and (2) another consciousness of the first consciousness present, concomitant with the first. If this be so, we would have to have also existing a consciousness (3) aware of consciousness (2) and a consciousness (4) cognizant of consciousness (3) and so on giving us an infinite regress. It may be answered that we need not go back beyond a second consciousness because we can take it as a fact just as opponents of the 'self-awareness' theory stop at a first consciousness. Again if one can use as an argument the infinite regress, the argument of an infinite progress is just as valid in the opposite direction. If a regress is possible to infinity in the former argument, it is just as consistent to suppose such a regress at its end, to turn about and go infinitely forward, till we stop at the object and wipe out consciousness altogether. We would then say not we are 'conscious of an object,' but simply 'object.' Between the infinite regress and the infinite progress, consciousness as such would seem to have little chance of being. How far this is true I shall attempt later to show.

Arguments however may be drawn from the so called physiological substrate of consciousness. Supposing each psychic state to have a physiological concomitant, consciousness of any object would necessitate special cerebral activity; awareness of such consciousness would also presuppose another set of brain cells active when the first are stimulated, and having a concomitant awareness of the first consciousness of the object, which runs along with the other set of cerebral cells. There would then coexist activities in two sets of brain cells, one parallel with an awareness of a psychic state, and this parallel with cerebral activity resulting from stimulation from without. Such a supposition would lead to all sorts of complications, and is moreover unnecessary, the 'parsimony of consciousness' which we believe in precluding any such hypothesis.

Again if we are conscious of mental activity as such, we ought to be conscious of it at all times. If awareness of it does

not always exist, there must be some transition; if so, where is this transition? Now we are not always conscious of this activity, as it is usually understood; moreover we may have great mental activity for a time with small or no sense of effort; small mental activity with great sense of effort; and reversely, there may also be great mental activity with correspondingly intense feelings; likewise in the case of little mental activity. The mental activity as such does not seem to be any measure for the degree of our awareness of it as it ought to be if it has any such concomitant awareness. Fechner's law should hold here as well as in the case of external stimulation.

I shall now attempt to show wherein this feeling of effort, strain, etc., consists. The feelings of strain present in moments of concentrated consciousness have long ago been pointed out by Fechner, and even before him by Tiedemann[1] and analysis was for some time satisfied to consider such feelings of muscular strain and tension as all that are present in this so-called feeling of effort.[2] Wundt however allows such *Spannungsempfindungen* but adds in addition his *Thätigkeitsgefühl* in moments of intense consciousness. Wundt has been variously interpreted; attacks against his theory have been directed chiefly from the standpoint that his 'feeling of activity' and his *Innervationsempfindung* are feelings of pure activity *per se*.[3] In the fifth edition of the Grundzüge, however, Wundt expressly states that the *Innervationsempfindung* can hardly exist as such; that what are so called, are simply motor images; and he proposes to substitute for this much misused term, that of *centrale Bewegungsempfindungen* or *centrale Componenten der inneren Tastempfindungen* (II., p. 31–33); and his *Thätigkeitsgefühl* he describes as composed of a combination of *Erregungs- und Spannungsgefühlen* (III., p. 252). We would then have simply the name; but the fact would be, according to Wundt's interpretation, that consciousness of mental activity as such is not possible.

[1] See Fechner, *El. der Psychophysik*, II., pp. 475–476; Tiedemann, *Untersuchungen über den Menschen*, 1777.

[2] See Ribot, *Psy. of Atten.*, p. 29; Ferrier, *Funct. of the Brain*, p. 464; Lange, 'Zur Theorie d. sinn. Aufm.,' *Phil. Stud.*, IV.; Münsterberg *Beiträge*, heft 2, p. 121.

[3] See Münsterberg, *Grundzüge*, I., p. 529, and James, *Princ.*, II., p. 493.

As components of the feeling of activity, there would then be feelings of strain, tension, etc., whether existing in the skin, and organs, muscles, joints or tendons; and whether peripherally or centrally aroused. Another factor which I think must be considered, is mental fatigue. Granting a physiological basis, any great mental activity would go along with a rapid discharge of cells, causing (1) an increase in the amount of cerebral matter, (2) a greater amount of heat, (3) a growing quantity of waste material, and (4) an increase in the flow of blood. Conditions thus existing would be different from the normal, and the total result would be a certain sensation of heaviness, of tension, of throbbing which would be added to any muscular feelings, etc., present.

In whatever manner it is considered, the feeling of consciousness of its own stream is a myth. When we consider what we mean by effort, this becomes still more evident. Effort put forth presupposes something to which the organism reacts; and something to which a proper adjustment has not yet been attained. A satisfactory attitude is reached only after a number of trials. Effort is possible both physically and mentally and all possible variations exist. The popular superstition that the effort felt is a measure of the work done still clings to the concept with many good people. 'To work by the sweat of one's brow' has become proverbial, yet the sweat and the effort do not necessarily show that any special work has been accomplished. In all cases the sense of effort shows simply that some incompetency transient or permanent, exists in the subject; or that too much has been undertaken; or that the difficulties have been too great; which simply means a lack of power in the subject for that special task. Sense of effort means that energy has been wasted as far as the accomplishment of the task is concerned; that the attitude aimed at has not been realized, or if so, only after a number of unsuccessful attempts.[1]

In mental effort we have a similar alternation of attitudes but in a weaker degree. This agrees with the feeling in many who have put forth physical effort that such sort is much greater

[1] Cf. Dewey, 'Psychology of Effort,' *Phil. Rev.*, 1897.

than mental effort, taken as such. To put it popularly, it is much harder to shovel in a ton of coal, than to think out some scheme of passing it along without shoveling. Some are inclined to place mental effort as greater than physical, because they look at the effects of the former. Mental effort is much more likely to leave after effects which may be injurious; but these have nothing to do with the effort as felt. The view of effort as presented does away with the objection offered to James' 'backstroke' theory by Stout, viz., that if feeling of effort arises from motor innervations, the actions themselves ought to give rise to a more intense sense of effort. As a matter of fact, they do.[1]

Thus far I have endeavored to show that neither by introspection nor by any hypothesis of a consciousness aware of its own stream, can we have any mental state in which consciousness does not have an object; and that in the present. I shall now try to show that the same holds for feeling and emotion.

The James-Lange theory is too well known to need any lengthy exposition. A brief presentation, may, however, be helpful for purposes of discussion. The theory can be set forth no better than as given by James. In his original and striking manner, he says, "My theory . . . is that *the bodily changes follow directly the perception of the existing fact, and that our feeling of the same changes as they occur* is *the emotion*. Commonsense says, we lose our fortunes, are sorry and weep; we meet a bear, are freightened and run; we are insulted by a rival, are angry and strike. The hypothesis here to be defended says that this order of sequence is not correct, that the one mental state is not immediately induced by the other, that the bodily manifestations must first be interposed between, and that the more rational statement is that we feel sorry because we cry, angry because we strike, afraid because we tremble, and not that we cry, strike or tremble, because we are sorry, angry or fearful, as the case may be. Without the bodily states following on the perception, the latter would be purely cognitive in form, pale, colorless, destitute of emotional warmth. We might then see the bear, and judge it best to run, receive the insult

[1] See James, *Princ.*, II. 494 ff. and Stout, *Anal. Psych.*, I., p. 64.

and deem it best to strike, but we should not actually *feel* afraid or angry.

"I now proceed to urge the vital part of my theory, which is this: *If we fancy some strong emotion, and then try to abstract from our consciousness of it the feelings of its bodily symptoms, we find we have nothing left behind,* no 'mind stuff' out of which the emotion can be constituted, and that a cold and neutral state of intellectual perception is all that remains. . . .

"If such theory is true, then each emotion is the resultant of a sum of elements, and each element is caused by a physiological of a sort already well known." [1]

Whatever the emotion be, we have a special form of consciousness, a feeling due to instinctive changes in our body. The statement as given by James in the beginning of his discussion is as he says, a 'crude' presentation of the matter; and one which has led to some criticism of the theory as a whole. When, upon seeing a bear, I feel frightened, such fright may be due to internal changes and muscle adjustments, giving rise to the emotion, and being then followed by further movements as flight, etc. Whatever these changes be, whether in the glands, muscles or internal organs, the emotion is due to them. The visual perception of the bear as such cannot cause fright. I see him in a cage and feed him with peanuts; meet him in the forest and run. The organic changes, in the one case absent, are present in the other.

Of what am I conscious in the latter case? Obviously not of the bear alone. There is also present consciousness of my body in a peculiar state; consciousness of my body in a special way, which I feel and call the emotion of fright. My body reacts in a certain manner; acts as a go-between and determines my future course of action. But the feeling is consciousness and not consciousness of the bear *per se*; nor consciousness in the abstract as some would like to believe. It is consciousness of something, and this something is my body or some portion of it.

[1] James, *Princ.*, II., pp. 449-453; see also Lange, *Ueber Gemüthsbewegungen*, 1887.

Our knowledge of our body in a special way does not usually exist at the time the emotion takes place. The emotion is not localized as here or there; it is simply felt; and connected with some outer object, the bear in the example taken. We do not see it; we do not hear it; but what is more important we do not localize it by the means of the sense of touch. The emotion in most cases is therefore felt, without being felt as here or there; nevertheless it is consciousness of an object, somewhere, and this object is our body. "Attend to an emotion, analyze it and it vanishes." When we try to dissect an emotion, to our mental state become added circumstances other than these originally present. When I try to examine an emotion, there is added the sense of touch, of localized temperature, pressure and the like. I then become distinctly aware of some portion of my body as a localized object, with a tinge of the emotional state. It is not true that the emotion disappears absolutely upon attention to it. There is present consciousness of the body in its disturbed state, plus whatever is added through localization, etc. But the consciousness of my body is then still accompanied by an emotional overtone. What we are conscious of in an emotion is simply our body as an object; we are conscious of our body in a peculiar manner; not visually nor in the usual manner in which we are said to be conscious of any object; but conscious of it without the visual and tactile constituents which almost always are present in our conscious states.

Objecting to the 'crude' statement of James, some have tried to show that what is present is not simply consciousness of the body in a certain state. For example, if emotion is consciousness of diffused organic disturbances, why is not some emotion caused by a cold shower-bath?[1] But surely the organic sensations are not the same in both cases; nor are the constituents alike. Visual, tactile and other elements enter in the latter case, which are not present in an emotion, and which would have no place in a supposedly resulting emotion; nor are there present during the bath any instinctive attitudes or tendencies which might be present in the emotion. Similarly,

[1] Stout, *Man.*, 2d ed., pp. 302–309.

the motor elements resulting from are not organic elements constitutive of the emotion and must not be confused with them. Whether a frightened moorhen runs or dives or hides under a bank makes little difference in his emotional state. The organic and bodily changes have already occurred before the actions succeeding the emotion take place.[1] The emotion need not be confined to consciousness of the leg muscles. Any objections of this kind do not touch the essential features of the theory; that in emotion we have merely consciousness of the body in a special manner.

An attempt is also made to carry emotion beyond the influence of body states by introducing ideational states and higher stages of consciousness. In an emotion there must occur disturbance of mental equilibrium due to furtherance or hindrance of preëxisting conative tendencies; or there may be present ideational excitement in addition to the body changes.[2] But what is disturbance of mental equilibrium but just this consciousness of body changes, sudden and instinctive? Disturbance of mental equilibrium means some change in consciousness, and such change is brought about by instinctive changes and adjustments in the body. Our consciousness, when our mental equilibrium is disturbed, is not consciousness of the disturbing object *per se*. The other constituents helping to form the total stimulation are the body changes described. Disturbance of mental equilibrium is simply another name for consciousness of the body in certain conditions, *i. e.*, for an emotion. In conation, too, there is present simply consciousness of the body in a certain attitude. Furtherance or hindrance of a conative tendency would mean nothing more than furtherance or hindrance of the body attitude, consciousness of such attitude being called conation, and change in it, disturbance of mental equilibrium. In both cases there would be present only consciousness of the body in a special way.

The ideational excitement above mentioned as an addition to the body changes refers specially to revival of ideas of a pleasing kind.[3] One under the influence of opium is said to

[1] See Morgan, *Habit and Instinct*, p. 201.
[2] Stout, *Man.*, 2d ed., p. 308, and Jodl, *Lehrbuch*, 2d ed., II., p. 365.
[3] Jodl, *Lehrbuch*, II., p. 365.

have, in addition to any bodily changes, ideas of a pleasing and exhilarating nature. Here again, however, we have the same thing masquerading under a different name. The emotional quality of any such ideas is due solely to the innervations, tendencies, changes brought about in the body. And such changes added to the coarser effects produced in the body by the opium, give the emotion; again, there being present nothing but consciousness of an object, *i. e.*, the body stimulated in a special way. Whatever name we give to the whole mental state, or to any part of it, all we have as the emotion is consciousness of our body; nothing else.

Finally the objection that emotions are too important in our lives, to be "the 'feel' of bodily attitudes, that have themselves no meaning" can hardly be said to hold. What are we without our bodies, and how is it possible to take any attitude without some feel of them? It is only as the attitudes are felt that we have meaning; the meaning is due to the attitude, and is the consciousness of the attitude.[1] The emotion does not come first and give the 'feel' to the attitude, but it is the attitude which first and last is the most important, the emotion, etc., being simply our awareness of such attitude. Without the possibility of attitudes we would be as nothing, and meaning would be impossible. Even if the emotion is thus 'reduced' to 'sensational' elements this need not disconcert anyone. There is nothing intrinsically wicked in holding this to be the right view, and if this be so, then let it be so. No matter what the emotion be reduced to, it will still be felt as an emotion, and for convenience sake, be so called. The name is the last thing about which to worry.[2]

II.

Many objections are usually raised against the thesis that in the feeling of mental activity and in emotion we are conscious of an object, *i. e.*, our body or some part or parts of it in a particular manner. In pure cognition, however, treating this for convenience sake as separate from emotion and volition, it is more evident that consciousness is concerned with an object, though exactly how, is not a point upon which all agree.

[1] See Dewey, 'The Theory of Emotion,' PSYCHOL. REV., 1894.
[2] Cf. Irons, *Psych. of Ethics*, 1903.

When I see a piece of white paper, I say I am conscious, of, or rather have consciousness of an object. When I see it, touch it or hear it crackle, it is for me an object. We say that consciousness is in some way concerned with it. As a piece of paper it is discriminated from a total field; it stands out; it is 'piece of paper,' at least, whatever else it may be, or whatever other relation it may possess. Considered in itself, it is for me an object. I may concentrate attention upon some writing on it, and this becomes for the time object, whatever else it be, or in whatever relations it stand. The same is true if I look, for example at the letter 'i' which is on such paper, or even at the dot over the 'i.' Each becomes in turn object, whatever else there be present. In the usual manner of expression, I have said, I am conscious of such object. But in the actual moment of presentation, I know nothing about mental activity, consciousness, soul, or what not. I have simply 'object.' This is all that the expression 'consciousness of an object' means.

In the example given, the 'object' is something which can be definitely localized; it exists here or there and has certain spatial relations. I am able to take a more or less definite attitude towards it. Object as commonly understood, carries with it the implication of spatial localization. We need not however restrict the expression to this narrow usage. I may touch something in the dark, without knowing its contour, color, or anything other than its touch. It is none the less for me, an object. So too I may hear a sound, and the sound is for me an object. The very expression 'hear a sound' shows the looseness of our terminology in this particular. I cannot have sound without hearing it, nor can I hear anything but sound. I do not say I touch a tactile sensation, or see a visual impression. I have an object in each case. I touch a bell; I see a bell; and so too I hear a bell when impressions other than auditory are concomitant. But the absence of such accompanying impressions need not drive us to the tautology of, 'I hear a sound.' Rather to be consistent, I hear something, I hear an object, I am conscious of it in a certain way. The same might perhaps be expressed in a more palatable manner, viz., 'I have an auditory impression,' but this would not change the state of affairs

in the least. Of course if 'sound' as commonly used carries with it the implication of objectivity, then, 'to hear a sound' means, 'to hear an object,' *i. e.*, to be conscious of it in a special manner. We would still have an object in such a case. In a similar manner the same may be shown to be true with taste, smell and vision, *per se*, *i. e.*, in each instance we have an object, or to put it as before, we have consciousness of an object in a special manner.

Whenever I am conscious of any part of my body, this becomes for me an object, just like anything else. I touch the piece of white paper, and become conscious of my finger, and of the paper, or of both. If any visual impressions coexist with the tactile, the tendency is to say, that there is some paper present. None the less, there is also present the object finger, whether such be neglected for the time or not. My attitude is more frequently taken towards the object, 'paper' or what not, so I neglect for the time the object finger. If my attitude is taken towards the finger, this becomes the predominating object. I am wounded, for example, in the finger with a pin, and I become conscious of the object finger, whatever else there be present. It seems here that the tactile sensation does double service; that we have awareness of two objects, and only one impression. Closer examination will show that this is not exactly so. If we had only the sense of touch, and nothing else, there would be no possible means of telling whether or not there were two such objects as finger or paper from the impression alone. We would have simply touch, touch, touch; there would be for us simply objects and nothing more to which we would have to adjust our attitude. But when there are coexisting visual or other impressions, these come in to give us the disparateness of the two objects, finger and paper, in the example given. While in the given case the touch is one, and alone would give us simply object, the visual and other impressions give us paper plus finger. In the dark such concomitant impressions are revived to enable us to take an attitude to the object, *e. g.*, paper, as object. If not we have simply some indefinite 'object' to which we react in a certain manner, depending upon our experience. An insect crawling across

my back will not give me consciousness of insect, plus consci ousness of back. All I have is consciousness of back, or at least, as with the child, of some object; I cannot look at my back, I have not seen anything crawl across; the visual impression is lacking; I am aware simply of 'back' or 'object' and take my attitude accordingly.[1] In the young child it is highly probable that such awareness is not definitely localized; that there is not 'back' but simply 'object' or even not this; there may be only a 'something' to which the attitude is taken. Where one finger touches the other at some place, or some other part of the body, I may become conscious of one or two objects, according to the attitude I take; but here we have not one, but may have two impressions, one part of the body stimulating the other. It is not my purpose here to develop any theory of external reality. Whatever be the process we can start with but 'object,' whether such object be our body or something else, and whether such object be called and named 'object,' 'something,' or what not.

A term which might be used instead of 'object' is 'experience' that is, in what are called states of consciousness, we always have an experience. Experience, however, has in it the implication of some more or less active self, soul, or what not, and leans more towards the side of an abstraction in the direction of such supposed self or soul. It seems that 'experience' is one step in the process of abstracting from what we have before us at any moment; that experience is rather an expression likewise, which includes the entire state at any moment. My experience also takes in my will attitude, my feeling and my cognition together; with a reference before and after. It seems better therefore to restrict ourselves to a term which can be used when we deal with these components separately. Object does not mean a scissure from the self or ego, or whatever else we choose to call some such hypothetical active principle. Object always carries with it a certain relation with the self. I have no object unless I am present, and without my being concerned, there can exist for me no object.

[1] Baldwin, *Mental Development*, pp. 119–134; Stout, 'The Genesis of the Cognition of Physical Reality,' *Mind*, 15, 1890.

Object as thus considered is not any supposed *ding-an-sich* Object is simply what is before me at any moment. I may abstract, theorize, and construct a philosophical system giving me a world of external reality apart, or supposedly apart from me (if such a thing be possible); and on the other hand I may build up a theory of consciousness or mind distinct from the *ding-an-sich*. But I must start with the object, for at any present moment this is all I have. It cannot exist without me; I can in no manner conceive any object entirely separate from me. Wherever there is for me an object, there must be some one conscious of it; and wherever one is conscious, he must be conscious of an object.

In so-called higher stages of consciousness, it is not evident at first sight as to what the object of consciousness is; and the temptation is to slide off into easy theorizing and speculation about mental activity, etc. In addition to what has been discussed in this connection, I think it safe to say that higher consciousness deals with images, which sometimes have future or past reference; with words and their meaning; and with relations.

The treatment of consciousness of objects which cannot be distinctly localized will enable us better to understand in what manner so-called images are objects. The popular division considers objects as belonging to a so-called real world, and images as constituting mental creation; the former pointing without and the latter within. But my image is an object, as is a sound. For my image at any moment exists somewhere outside of me in a more or less dim and hazy manner; and like a purely visual or auditory impression it is not definitely localized as here or there. . . . So too, an image is an object in kind like the impression. Abstract from the visual impression all motor and tactile concomitants, and we have an object. It is now and present, and I take an attitude towards it. By a criss-cross check system of impressions, I stamp the one as real, and the other as image. But in the so-called real object, I have constituent aids to the visual image, or impression which are important in determining the attitude taken. The visual image usually has none such, and exists almost purely as visual.

Another popular hypothesis prevails which operates against the calling of images objects. An object is considered as being real; as being constituted by something which has existence outside of consciousness as it were. Now in any moment, in what is actually before me, I know nothing of this; I have simply object. I may build up my system later, and say this object is real, that is not. But this has nothing to do with the actual moment as such. Moreover the image can be considered as having some external and real substratum; only in this latter case, the 'thing' influenced consciousness on some former occasion, and its effects are still present. A real thing, whatever it be, if existing in the former case, can be said just as well to exist in the latter case; the difference being that in the latter its stimulation still has force and still is operating. I bring in the supposed *ding-an-sich* simply to enforce the view that what is called an image may be considered an object as are the objects of consciousness in moments of perception.

A cheap and easy argument against association is that consciousness is teleological; strives towards an end; deals with the future as well as with the past; while association deals only with the past. As a matter of fact, we have neither past nor future consciousness; all I am conscious of exists in the present, and consciousness of the past is not past consciousness, nor have we future consciousness in consciousness of the future. The pastness or futureness of the image is simply the stamp which it has which enables us to take our attitude, and adjust ourselves to it. What we call the pastness of the mental image is simply our attitude towards it, strengthened sometimes by the addition of some word. And such word again, as I shall try to show, has meaning only because of our attitude caused by it. When I try to bring back the experience itself as past, all I have as an immediate awareness is a tendency to turn around and go back. I can get back into the past no further; I am held to the present. The present remains still with me; the past is no more. We are satisfied to stamp a thing with the word 'past,' 'yesterday,' or what not, and act accordingly. Any more we need not, and more we have not. Those peculiar characteristics of the present image, constituted either by its

qualities, by organic sensations, motor tendencies, or by some word connected with it, are all that we are immediately conscious of in a memory image; and these are sufficient to regulate our conduct. But pastness as such we can never experience. I have not attempted fully to analyze what is in the present which determines my attitude to it as past. This has been done rather fully by James, Höffding, Lehman, Münsterberg, Wundt, Bergson, Sollier and others. Whatever it is, it is objective, *i. e.*, there is present some object or objects, either our body or some part of it, together with a dim and indefinite object which we call the image and perhaps also a word; these enable us to guide our action; to take our attitude. The same holds as regards future reference.

The aid given by words in memory is greatly increased in the higher stages of consciousness. In fact, without words, thought could hardly go on. In trains of the most abstract thought, consciousness can be occupied only with words, or word images. The word as spoken, is constituted by impressions of sound, plus motor and tactile impressions of the throat, tongue, mouth, etc. That is to say, we have a combination of impressions, are conscious of a number of objects; and the persistence of such objects in more or less constant relations enables us to use them at all times for the guidance and determination of our attitude. We are prone to look at the word as existing first, and then work back to the impressions. But what we have is simply a number of impressions. These form the word, they are the word. In the word image, likewise, we have simply a skeleton, as it were, of the actual impressions, but enough is present to enable us to adjust ourselves as required. Whether the image is motor, visual or auditory, we are conscious of dim and hazy though constant and persistent objects; though dim and hazy as felt impressions or images, they remain the same or nearly so; they persist in their relations, at different times, and so are of use to us in facilitating consistent action.

Consciousness of the object constituting the word or word image does not give us thought; what is present is simply a number of objects; or, to put it more popularly, a number of

impressions and images. Taken as such, without any concomitant attitude, the prattle of a child is the same as the learned discourse of a philosopher. What differentiates the one from the other is the meaning attached to the one, and lacking in the other. The child's word 'self' is exactly or nearly the same as the philosopher's. There is present simply a number of impressions, motor, auditory or what not. But the meaning given in the latter case makes the word something different from what it is in the former. What we have in the word as such is, therefore, only a number of impressions and images which remain about the same for the same word. And impressions and images, as I have tried to show, are our consciousness of objects.

Words enable us to facilitate our reactions, by acting as 'short cuts,' as it were. Instead of adjusting myself now to this book, now to that, I react simply to 'book' which covers all such cases insofar as the term 'book' is applicable. My attitude is at once determined in its general outline by the word, and naturally so, since it is only after repeated experiences that my attitude towards book has been beaten out, partly by me, partly by the external object. Usually words are connected with certain attitudes which constitute what we call meaning, and, as such, is what is present in thought. In words we are conscious of more or less determinate objects, and in attitude, we are conscious of our body in a specific manner, or simply of images of such attitude or tendencies to such attitude, such images being essentially motor, and in the specific cases concerned constituting the attitude.

There is nothing more mysterious in the word than in the actual object; though both are mysterious enough. In each case we have certain impressions, we take a certain attitude, though in the former our attitude is less filled in and determinate. When I see a chair, I have in the main a visual impression, to which I take a certain attitude. Now for this visual impression I may substitute another, that of the corresponding word, and take a corresponding attitude. The word is an object to which I react just as in the case of the chair. I must make certain allowances in the case of the word, but there

is nothing to prevent my attitude from being essentially the same. I may wish to make my attitude more determinate by looking at a real chair but the essential characteristics of the attitude are there just the same. I read for example, 'The chair is broken,' and I can take my attitude just as well whatever visual impressions I have, whether of the words, or of the corresponding objects. I take a certain attitude. In the case of the word moreover, I can pass it on, tolerably sure to bring about a certain attitude in my reader or hearer, something which I may not be well able to do with the thing itself. Meaning is something which is not necessarily restricted to the word. All objects have meaning, whether such meaning stands out or not.

As in sense impressions in which we pass by well known objects without any special reaction towards them, in which the meaning is not specially emphasized, so too, well known combinations of words may be passed by. There is in the attitude towards both, what might be called a feeling of quiescence. Just as, when I see my well known chair, I do nothing in particular, so in reading an easily understood combination of words, I simply read on. When the combination of words is not well known, I try to substitute others towards which I can take an attitude, which have meaning. When the attitude taken gives this feeling of quiescence, the meaning is understood. It is evident that since the words *per se* is simply a combination of impressions, and the meaning is due to the attitude taken, I may have a word with the impression as such emphasized, or the word with the attitude emphasized. Where words are closely connected with the attitudes toward them, the latter may therefore be emphasized at the expense of the impression or image. That is to say, in reading, we may pass rapidly over the words and dwell chiefly on the meaning. The words as impressions are suppressed, and more place is given to the attitude constituting the meaning. To be more exact, I might say perhaps that consciousness of my attitude constitutes the meaning; but if we consider that no object can exist without consciousness of it, that object has in it the implication of consciousness, it remains the same whether I say 'attitude' or

'consciousness of attitude,' just as 'there is a book before me' equals, 'I am conscious of a book before me.'

The attitude which gives rise to the meaning of an object or word is a rather complex thing, and is not easily analyzed out of the total mental state. We develop it gradually. Before something for the first time, I act towards it in a certain manner, pick it up, perhaps taste it, look at it and so on. Processes like this repeated a number of times will tend to create in me a certain manner of acting in the presence of this thing, whatever it may be. The object becomes stamped, as it were, as a thing to be treated a certain way. My experience with it at different times will tend to make me react a certain way, though any actual reaction be not always made. I am ready, as it were, to act. So when I perceive the name of the thing I take an attitude towards it; and upon repeated experiences with the name, this attitude becomes more and more a mere tendency as compared with its first occurrence. By attitude, as I have before suggested, I mean certain body changes felt either as actual movements, innervations, etc., or as dim images. As far as I can see, the attitude taken where the object or word is well known, is characterized by a feeling of ease or quiescence. By this I do not mean that there is present a pronounced feeling which stands out, as it were, like a signal to tell me all is well. Rather I am in that state in which the object or word does not tend to rouse in me any special attitude; it does not stimulate me to any new effort of adjustment. After repeated experiences with the same object, by a process of analysis, I find that I am in a certain condition; that I have a certain bodily feeling, when I have nothing to fear from the object; when no further reaction is necessary; when the object is known. I do not call it a feeling of indifference, because it does not belong to the pleasure-pain category, being rather the feeling of the body when no special reactive tendencies are present. Such a condition I choose to call a feeling of quiescence. It is marked by the absence of any special feeling and is simply consciousness of the body in a certain condition. Where the word is well known there is present this feeling of quiescence as in the case of the well-known object. I may do nothing in its pres-

ence, but I can do what is necessary. I know I can react properly; I feel I can (such knowledge and feeling being implicit in the bodily state which serves as a sign), and therefore I do nothing. When such certainty is not absolute this attitude becomes more explicit, as a succession either of images, of innervations, or of actual movements, sufficient to result in an understanding of the word, to make the meaning clear, to enable the proper attitude to be taken. If the words themselves cannot give rise to a proper attitude, other words are substituted till a proper process of reaction or tendency in this direction be reached. But such process of explication goes on only so far as is necessary to ensure a sufficiently accurate attitude, *i. e.*, till the meaning is well enough known for the purposes in hand. In meaning, therefore, we do not have any independent 'higher consciousness,' but here, as elsewhere, consciousness is occupied with an object in the present, such object being the body or some part of it.

Thought is concerned wholly with meaning and relations, and it is well to consider in what relational consciousness consists. Expressing symbolically, the fact that one object, a, stands in a certain relation to another object, c, we have:

$$aRc,$$

or, to be more exact, since c might also be in relation to a by the fact of a's relation to it, we would have

$$aRcR'a.$$

Considering 'object' in its wider significance, as including 'image,' a and c may both be objects or images; a may be an image and c not, or c an image and a not. Again, the two may be in consciousness together, or separately, or alternately, and then together; a and c are objects, whether we consider them as images or real objects. The question now is, What is R? Does it depend upon the existence of a and c? Will it fall with the disappearance of the two, and from the latter must be differentiated the question, Must a and c first be before R, and if this is so, can R then exist alone?

Thus far I have tried to show that consciousness must have an object, and I do not see how relational consciousness can be

an exception to the rule. R is obviously not inherent either in a or in c. I may have a alone, or c alone: likewise I may have $aR'cR'''a$. In the former case; a alone is taken in a relational and not in perceptual sense; the latter always having the object in a background, and thus in a relation. But in perception we are not specially conscious of the relation; only when we think over the matter does the relation stand out, and then the consciousness is no longer perceptual but relational. It is also safe to say, that if a and c never existed, R might or might not have existed. Whether, once having existed, it can again take place without a and c depends upon what it is. Whenever I am conscious of a relation as such, that is, whenever I compare, or think about objects and their various connections, all I can find besides awareness of the objects *per se*, is a special attitude which I take towards either or both of them, in their various connections. This attitude must be present before I have the relation. I may compare the length of two sticks, and have besides object a and object c, movements of my eyes passing from one to the other. But such movements are simply the motor concomitants which with the visual impressions go to form my percepts of the sticks, a and c, of the distance between them, and the like. When, however, I find aRc, my attitude is taken; I react towards a, not simply as a, but, as, for example, 'a shorter than b.' If now I wish to make my attitude more explicit, I may take a instead of c, to measure, or to lay across a space, or to throw away, or to react, as the case demands. Once having experienced R, in the example given, 'shorter,' this can stand without the existence of a and c, from which it arose, being now fixed with the word; as a word it has meaning, and may be used in a number of cases. In a relation therefore, I have simply the attitude taken towards a number of objects in certain connections. The formula, aRc, then becomes,

$$aBcB'a.$$

There are present coexisting objects, viz, a, B, and c, in which B is the body in a certain condition; or to put it differently, the consciousness of the relation is only conscious-

ness of the body in a special manner. 'Transition in consciousness' would mean nothing more than this.

III.

Thus far I have been occupied with the seemingly insignificant attempt to show that consciousness, whether in the highest stages of abstract thought, or in the so-called 'feeling of self-activity' is always occupied with an object, either the body or some other object. If then we are careful to explain what is in the field of consciousness at any moment, it is evident that we can explain it just as well by speaking of object in this broad sense, as by using psychological expressions, as image, sense of effort, or what not. All such explanation is individual however, and applies only to the moment in question. To explain a number of different moments we would have to use different expressions in each case, which necessarily would lead to confusion. By generalizing and using such expressions as idea, feeling, etc., any formula or theory will hold good in such general terms for any number of instances. We must however, have, at the bottom of such general terms an object or objects, from which we have abstracted, and from which in crucial instances we can abstract. But we must be careful not to reverse the process.

The usual expression, and one which we have been forced more or less to use in the preceding two sections, because of the current terminology, is that 'consciousness' is concerned with an object. But I can have no object without consciousness; I must always be conscious of an object; the relation which we call 'consciousness' is already implicit in the expression 'object'; 'consciousness' a supposed something, would better be said to be in relation to or aware of the 'real' another supposed something, both of which being abstractions from the object before us.

I may show this somewhat more clearly as follows: "granted a something called consciousness, we find this always in relation to something else, call it 'ding-an-sich' or what you will. If a 'ding-an-sich' be denied, 'consciousness' can just as well be refused. I prefer to speak not of the relation of conscious-

ness to its object, since consciousness is implied in object, but of the relation of consciousness to some real. Neither of these has existence for me as a separate reality, but only as an abstraction. I have simply 'object' at all times. The real and consciousness in certain relations give me 'object.' Expressed symbolically, we would have,

$$O = a' Rx,$$

i. e., the real in relation to consciousness gives us 'object.' But I have no more right to speak of a' as related to x, than of x as related to a' in some manner. We usually think of a one-sided relation, but there is rather an interaction between the two if any. This will give us,

$$O = a' RxR' a',$$

in which as before, a' is the external real, x is consciousness as a real, and R is the relation between them. But any real before reaching this supposed consciousness, must do so through the medium of the body or end organs. Considering simply the relation between the end organs and real, and supposing such relation reciprocal, we have,

$$a' R'' b' R''' a',$$

in which b' does not mean body as object (for this has in it the implication of consciousness), but body as real. Such a process takes place for example in instinctive reactions of which I am not conscious. I chose to call this interconnection, the end-organ-process. To be conscious of this, it must be in relation to the supposed x or consciousness as real. This will give us,

$$O = (a' R'' b' R''' a') RxR' (a' R'' b' R''' a'),$$

i. e., end-organ-process is in relation to consciousness which again is in relation to end-organ-process. But again, such process is mediated by what we call the brain, which we may represent by e', this not signifying brain as body or object but brain as real. We shall have the rather awful formula,

$$O = [(a' R'' bR''' a') R'''' a' R' (a' R'' b' R''' a')] Rx$$
$$R' [(a' R'' b' R''' a') R'''' e' R' (a' R'' b' R''' a')]$$

which means that some real, a' acts on the end organ b' which

reacts on a', resulting in the end-organ-process, which stands in some relation to the brain e'; and e' stands in relation to such process; the whole may be called the end-organ-brain process. The whole is in some relation to x, which again is in relation to the whole. It is of course a question whether in all cases there is a reciprocal relation between end-organ-process and brain before consciousness is possible, or whether we have simply, end-organ-process, related to brain, related to consciousness directly. This would however have no effect on our conclusions. Relation between mind and body means nothing without the action of reals on mind, through body, which real may be the body itself. Whether there be an interval of time between or not does not affect the validity of the formula. For the real may have been in some relation to the end-organ-process, which was in relation to the brain, etc., on a former occasion; the relation however still holds when the occurrence has past, though the relation is now perhaps weakened by the lapse of time, as when we have an image. What the final relation to consciousness is, whether one of parallelism, interactionism, causation or what not, we cannot tell.

The formula as given will do for discussion concerning reality consciousness, and the like. It is seen that in the first place, consciousness is just as much a *ding-an-sich* as the reality; and those who try to connect their experience with reality, or to build up an external world by some connection with consciousness, of which they think they are directly aware, are indulging only in academic juggling with terms which are merely abstractions. Consciousness is simply an arch concept covering all such conceptions as are found by abstraction from the object, in psychology; and any system of reality is likewise the result of abstractions in the other direction. If it be asked how one can possibly construct any psychological or philosophical system when there are present only objects, the answer is simple. We get no nearer the reality in either case but simply add a number of other objects to the one in hand, either for purposes of speculative amusement, or actually to facilitate our adjustments to such objects, as in science, whether psychology, electricity, or what not. We have then instead of O, alone,

$O + O' + O'' + O''' + O''''$, etc. What the reality is we can never know. It is bound up in some manner with another reality, the self, consciousness or what you will, and all we have is the immediate object. This is as near to the reality as we can get. It seems indeed remarkable that men should write learned treatises proving by rather hair-splitting arguments that so and so is the reality, when they have as much of the reality as they can get directly before them. Any system of philosophy which does not in some manner enable us to react more accurately to the object, is simply a mental gymnastic, or an academic word play. And if any system aid us in our adjustments, then what we have is not the reality, but only a working hypothesis as to what it may be, such hypothesis being considered valid as long as it can stand the test of our experiences according to our present knowledge. And such hypothesis consists of a number of other objects, O, O', O'', etc., whether such objects be words, symbols, or what not, which we are able to use for reactive purposes in our present life.

It has been said that 'all the choir of heaven and furniture of the earth' are, due to the research in psychology, nothing but sensations. This is not so, for what we have is first the objects, and then we may abstract, and by a process of reasoning conclude we have psychic states called sensations. If the sensations are considered as such, they come in only as a disagreeable overtone; the objects are still for us, 'the choir of heaven and furniture of the earth.' So, too, God, freedom and immortality, *as real, we can never know in our present state.* What lies beyond the present object, likewise is out of our reach, if it be not object. While we are restricted to the present object, still this does not restrict reality. We are accustomed to let one object, as a word, stand for some other, as a thing. So, too we can think of the thing as standing for some other, whether the real, God or what you will. We do not build up the world from sensations; rather we build up a system of sensations, etc., from the world, by abstraction from the objects before us.

While many will agree to the premises in the first two sections of this paper, it is necessary to pin them down by some

formula, to keep them from wandering into the airy regions of abstraction and speculation. With the above formula before one, it is possible to check the often too exuberant imagination. How the results reached affect the unity of conscious as usually stated, I shall discuss if possible in another paper. I have ended practically with the above formula, because it suits all purposes of discussion. It is seen that in the formula, a', b', etc., are represented as passive lumps; whether the relations result from them, or from some external power is not given. Now, supposing that the reals, a', b', etc., have some spiritual guiding element, we have a formula which I hesitate to put down. Granting a reactive guiding principle to a', b', etc. and representing this by y', z, etc., and considering that the reactive principle of e', is not consciousness but only what it has in virtue of its organic nature as any end organ or bodily part, we have:

$$O=[\{(a'ryr'a')R''(b'r''zr'''b')R'''(a'ryr'a')\}\ R''''(e'r''''r^{\nu}e') \\ R^{\nu}\{(a'ryr'a')R''(b'r''zr'''b')R'''(a'ryr'a')\}]$$

$$R \times R'$$

$$[\{(a'ryr'a')R''(b'r''zr'''b')R'''(a'ryr'a')\}R''''(e'r''''ur^{\nu}e) \\ R^{\nu}\{(a'ryr'a')R''(b'r''zr'''b')R'''(a'ryr'a')\}]$$

in which y is the reactive principle of a', z of b', and u of e'. The other terms and relations are the same as before. If we consider that the real a' has in it and implies some guiding spirit, then in the last formula, by further abstraction, the a' should be a'', etc.; or leaving the a' as it is with all its implications, we have the formula on page 246.

In closing I would emphasize the necessity of looking at everything in the third section of the paper as so much abstraction; of remembering that all that is present before us at any moment is an object of some kind or other; and finally, of rejecting any simple formulation as aRx, and the like in dealing with the relation of thing to consciousness. As I have tried to show the relation is much more complex.[1]

[1] The MS. of this article was received February 16, 1905.—ED.

A MOTOR THEORY OF RHYTHM AND DISCRETE SUCCESSION. I.[1]

BY R. H. STETSON,

Beloit College.

I. Method of Experimentation.[2]

Tables I., II., and V., were prepared from measurements of records taken from up-and-down movements of the hand and arm. The subject held a baton to which a delicate rubber cord was attached. Through guides this cord passed parallel to the axis and close to the surface of the kymograph cylinder. The writing point was attached to the rubber cord itself and a slight torsion was sufficient to keep it pressed against the surface of the drum. The movements were approximately in the same plane, though the records were not materially altered if the baton deviated from the plane. This prescribed path of the baton was the one limitation to the free movement of the subject. The pull of the rubber cord was so slight as to be practically imperceptible when combined with the weight of the baton. By varying the distance of the writing point from the fixed end of the rubber cord, the ratio between the length of the stroke and the length of the record could be varied so that the subject might beat as long a stroke as he pleased. The records taken were all about one fourth to one sixth the amplitude of the actual stroke.

Tables III., IV., VI., VII., were prepared from records taken of the finger tapping on a key, or rubber tambour, and from the movement of the foot in tapping on the floor. The record of the finger was made by a Marey tambour, or an electric marker. In the case of the foot, the heel was kept in position by cleats on the floor, and the foot was made to move up

[1] The MS. of this article was received September 3, 1904.—Ed.

[2] The experimental work on which this paper is based was done in the Beloit Psychological Laboratory recently founded, under the direction of Prof. G. A. Tawney, by the administrators of the Wm. E. Hale Fund.

and down between guides. The stylus was attached to the sole of the shoe and wrote directly on the kymograph drum. The method of recording the beat of the foot directly was satisfactory; the friction of the guides could not be detected, and the record was that of a foot tapping time under normal conditions. The usual precautions in dealing with a double kymograph record were taken.

II. Classification and Definitions.

1. *Classification of the Various Kinds of Rhythm.*

There are many different forms of the rhythm-experience. One hears of the rhythm of prose, of the rhythm of bird music and of animal calls, of the rhythm of walking and rowing, of the rhythm of simple taps or of 'simple sound series,' of the rhythm of verse, and of the rhythm of music. Wide differences are recognized, and some classification based on the causes of these differences is important for a theory of rhythm.

A common classification is based on the 'content' of the rhythm, a convenient and obvious basis of classification. The simple sound series, or a simple movement series, is assumed as the form of 'pure' rhythm, and all other forms of rhythm are deviations due to the nature of the 'content' which modifies the 'pure' rhythm.[1]

The material rhythmized is conceived as an antagonistic force which destroys the regularity and therefore the 'purity' of the rhythm. The more elaborate the 'ideational content,' therefore, the less regular the rhythm and the more must groupings depend on a cause foreign to the rhythm.

By this method rhythms are classified as (1) simple series in which the content is reduced as much as possible and the rhythm is perfectly regular; (2) musical rhythms in which ideational content of a certain type is present; melody and harmony enter in and partly determine the nature of the groupings which the rhythmic forms present, (therefore the rhythm is more irregular, less 'pure' than that of the simple sound series); (3) the

[1] Meumann, E., *Phil. Stud.*, 10, S. 310, etc. Followed by MacDougal, R., Psy. Rev., '02, 9, p. 476.

rhythm of verse in which a content of a much richer and more independent character has a much greater influence in the formation of the various rhythmic groups, and indeed practically dominates the grouping process and the rhythm *per se* is at a very low ebb.

The adherents of this system of classification might have carried the process one step further, and found in prose rhythm the complete domination of the ideational content and the consequent complete elimination of the 'pure' rhythm. But it does not then appear how rhythmic prose is to differ from unrhythmic prose.

This classification of rhythms by their ideational content is worthless. It is based on a hasty generalization of the relation of artistic form to artistic content, and when worked out is simply at variance with the facts. Rhythm as a form in music and verse is in the same case with symmetry in the spatial arts, or logical organization in written composition, or the principles of harmony in musical composition. The material does not war with the form and wrench it from its true proportions. In art works involving rhythm, the rhythmic form is not distorted by the material in which it is embodied. It is rather made by that material, and the most elaborate rhythms would be pointless and hard to grasp without 'content.' Anything that happens to rhythm at the hands of the true artist in his treatment of his material will not affect the 'purity' of the rhythm; it will be just as much a rhythm, in every sense, as the barest set of monotonous sounds that was ever clacked out by a laboratory apparatus. As a matter of fact, the artist observes certain requisites of rhythm which the laboratory worker frequently overlooks.

The classification by modifying content does not represent the observed facts. It is a sheer assumption that regularity is the characteristic of the 'pure' rhythm, but granting for the moment that it is, it is easy to show that the three classes, (1) simple sound series; (2) music; (3) verse, do not show less and less regularity as the theory demands. Owing to the construction of most laboratory apparatus, the simple sound series have usually been objectively regular, but it is easy to prove that very

wide irregularities can be introduced into such a series without destroying the rhythm. Just as great irregularities are possible as in the case of verse with its rich and definite content.[1]

According to the classification by ideational content, musical rhythm should be less regular than the rhythm of the simple sound series. But the fact is that it is only in music that a regular quantitative system has been worked out and applied. It is only in music that delicate and complex rhythms demanding minute and accurately differentiated intervals are possible. The many mechanical devices for producing music are witnesses to an exactness in musical rhythm intolerable elsewhere. Instead of being 'modified' and less 'pure' because of an ideational content, musical rhythms are by far the most regular and the most elaborately wrought in the whole range of rhythmic experience.

As to the regularity of the rhythm of verse, it is true that ordinary verse is read with extreme irregularity. And yet this irregularity is in no wise essential to verse rhythm. Series of nonsense syllables and nonsense verses may be, and usually are read with as great regularity as that of the ordinary song, or of the simple sound series. That the ideational content has little to do with the rhythmic impression is apparent when one listens to the reading of verse in a language of which one does not understand a word. In that case the effect is not unrhythmical. We do not miss the content; we do not feel that the factor which determines the unities and the grouping is lost. The verse has not become mere chaos which must be ordered by an unknown content before it can become a satisfactory rhythm. Not at all; one often notes rhythmic peculiarities and beauties not so apparent in a familiar tongue.

Moreover, it is worth noting in the case of these three divisions, that a form may be transferred, without any change, from one to another without losing its satisfactory rhythmic character. If a simple sound series like the striking of a clock is given a set of melodic intervals, the resulting melody does not show any clash between its content and the 'pure' rhythm in which it moves. One method of piano teaching which has

[1] Stetson, R. H., 'Rhythm and Rhyme,' *Harvard Psy. Stud.*, 1, p. 420 ff.

considerable vogue compels the student to translate his composition into a series of clicks at a mechanical keyboard, and thus to master the technical difficulties before it is played at the piano. The clicks of the mechanical keyboard used are precisely a simple sound series, and the rhythms intended for a musical composition with an ideational content have been translated verbatim into this simple sound series. But the rhythm does not therefore suffer, nor is there any feeling of some lost 'principle of unification.'

The content has something to do with the selection of an appropriate form of rhythm, but, that form once selected, it does not enter as a factor into the rhythm.

In place of the untenable classification based on a modifying content, a classification based on the nature of the rhythms apart from their content is possible. The series of simple sounds, the rhythm of verse, the occupation rhythms like walking, the rhythm of prose, and the rhythm of bird songs are all composed of a single series of sensations.

But it is obvious in the case of many musical rhythms, of some tattooes, of patting time for dancers, etc., that the total rhythmic effect is not produced by a single series of beats. Certain rhythmic forms, like  , we cannot produce with one hand. At least two processes are working side by side in such cases; there is the accompaniment and the melody, or the time-keeping slow beats against the more elaborately figured primary rhythm; often there are three or more distinct lines of beats playing side by side, now coinciding, and now striking alone. This is no mere matter of mechanical convenience in producing the rhythm; it is heard as two or more processes and so noted in our musical scores. It may be objected that many rhythms which are essentially musical have no apparent accompaniment. For example a melody may be given with or without an accompaniment, without essentially changing its rhythm, which is first and last different from the rhythm of verse. *Apparently* the melody has no accompaniment, but actually the melody has an accompanying rhythm which finds a real em-

bodiment in the organism of the performer and listener. Every melody has a 'time,' a definite 'takt'; it is in 2–4 or 3–4 or some other measure type. This definite underlying beat is the simpler, broader rhythm, always observed, and always felt, without which the rhythm of the melody would become a single rhythm. That performer and listener keep this takt means that it must have some physical embodiment, some corresponding movement, for without such movement, no realization of the two beats to the measure or of the three beats to the measure would be possible.

Rhythms, then, may be classified into two large divisions:

1. Rhythms consisting of a single series of beats — *e. g.*, simple sound series, ticking of clock and metronome, verse, prose rhythm, bird songs, occupation rhythms, etc.

2. Combined or concomitant rhythms — *e. g.*, musical rhythms in all their forms, whether accompanied by changes of pitch or not, dancing.

2. *Meaning of 'a Motor Theory of Rhythm.'*

Laboratory investigations recently published[1] assume the motor explanation. But thus far, little has been done in applying the motor theory to the details of the rhythmic phenomena, and it is by just such a thoroughgoing application that the theory as a principle of explanation must stand or fall. As a general theory, the motor hypothesis needs no defense. Its only competitor was the 'mental activity' theory which is manifestly incapable of explaining the peculiarities of the unit-groups and of the larger groupings. All of the observed facts of rhythm are for it simply arbitrary and unexplained, and its suggestion that content may play a determining part in a rhythm is worse than useless.

When one says that rhythm consists of a series of sensations of movement, or, of a series of sensations of movement in which other sensations (sound, sight, touch) occur precisely as if they were produced by that movement, and that the rhythmic group has the unity of a coördinated action, it is important to know in

[1] Wallin, J. E., *Stud. Yale Psy. Lab.*, '01, 9, p. 130; MacDougal, R., Psy. Rev., '02, 9, 464 and ff.; Miner, J. B., Psy. Rev., '03, Mon. Sup., 5, no. 4, p. 34.

just what sense the word 'consists' is used. It is evident that the mere presence of the movements which might be the basis of rhythmic experience does not imply the perception of that rhythm. The muscular apparatus whereby the sensational basis of rhythm is produced, is developed in the lower animals. Many of their actions are rhythmical, and the parrot probably reproduces rhythmic forms, but no one would credit the animals with a sense of rhythm. The trotting of a horse produces a vigorous rhythm, but one has only to listen to a well-matched team veering slowly into perfect unison, and veering just as gradually out again, to realize that their trotting is rhythmical, but that they have no sense of rhythm. The simplest suggestion would be a 'center' which combines the motor sensations to a rhythmic perception or a rhythmic emotion. But the multiplication of 'centers' never simplified a problem; it is much more nearly in line with what we know of coördination to assume that rhythm is simply a special form of the ordinary coördination of movement-experience. The Wundtians, who insist that rhythm is primarily an affective experience, can always treat the movement basis of rhythm as Stumpf[1] has treated the Lange-James theory of the emotions, insisting that there is an antecedent central process involved.

The question whether the affective aspect of the rhythm is the essential aspect is really part of a much larger question. If all forms of artistic synthesis, and indeed of any unity, are affective in character, then rhythm is to be so classed. If symmetry, and the metaphysical demand that the world be one, are primarily felt and not perceived, then rhythm is felt and not perceived. The same concrete rhythm may have at different times all shades of affective coloring from pleasant to disagreeable, and must pass the indifference point. Any series of acts is capable of just such changes in affective coloring. To the writer, the simplest form of the rhythm-experience seems simply a perception of a peculiar type of likeness and repetition in a movement-series. Whether or not it is primary no one can deny the importance of the emotional in rhythmic experience.

[1] Stumpf, C., *Zeitschr. f. Psy. u. Phys. d. S. org.*, '99, 21, s. 64–5.

It remains to consider in view of the motor interpretation the distinction between rhythms when merely perceived and when produced by the subject.

The movements involved in the production of a rhythm are always at hand as a basis for the experience of the produced rhythm. But one has as vivid and satisfactory a sense of rhythm when one merely *hears* (or sees, or feels) the series. Where are the movements at the basis of such a 'sensory' rhythmic experience? The body is provided with muscles capable of producing rapid and varied movements not visible to ordinary observation; among these one looks most naturally to those organs which have to do with the production of rhythm. Many musicians keep the takt by tapping the foot, and strains of the muscles of the leg often constitute the silent rhythmic response. Others tend to move the head or the trunk in time; careful observation of a concert audience will show both these types of motor rhythmization. But the most important natural rhythm-producing apparatus is the vocal apparatus. Musicians are frequently trained to count, and suppressed counting is frequent. The tongue is extremely mobile, and the muscles of respiration play a frequent part in rhythmization. The writer finds rapid series rhythmized by slight movements of the muscles of the tongue and perhaps of the throat, in conjunction with the expiratory muscles which mark the main accents. Every rhythm is dynamic; it consists of *actual movements*. It is not necessary that joints be involved, but changes in muscular conditions which stand in consciousness as movements are essential to any rhythm, whether 'perceived' or 'produced.'

In developing a motor theory of rhythm there are certain principles of explanation that are barred. They have frequently found a place in discussions assuming the motor basis, but they will not play any part in the present attempt at a motor explanation.

Analogies drawn from space do not help. A pause is frequently represented as a dividing space; and often the pause is supposed to separate, and therefore to unify the groups.[1] But unless motor changes can be shown to take place during the pause, the pause has no significance.

[1] Wallin, *loc. cit.*, p. 92; Miyaki, I., *Stud. Yale Psy. Lab.*, '02, 10, pp. 16 ff.

Nor does the logical supposition that as single beats are combined into unit-groups, so unit-groups may be combined into phrases, phrases into periods, etc., constitute a legitimate method of explaining the larger groupings of rhythms (Wundt and Meumann). As will be seen later, the nature of the larger groups is entirely different from the nature of the unit-groups.

Judgments of temporal equality or inequality play no part in the rhythm experience.[1] The time judgment is much too vague to determine rhythmic intervals, and accurate judgments of time founded on rhythms are secondary and derived.

Explanations based on physiological rhythms, such as that of the heart,[2] or of a supposed rhythm of the nervous discharge,[3] can avail nothing. Like the 'mental activity,' such explanations fail to account for the wide variations in tempo, and for all the peculiar facts of the unit-group and of the larger groups.

Imagery, or 'central motor discharges,'[4] or 'mental beats'[5] have often been invoked as possible vehicles for a rhythm. Imagery undoubtedly does play an auxiliary part in any rhythm, but that it can actually constitute a rhythm seems more than doubtful. A theory of rhythm in which the essential process is phrased in strictly peripheral terms is safe from the vagueness and uncertainty of the concept of mental imagery. Such a theory could be easily translated into terms of 'central motor discharges'—if their existence should be demonstrated, and rhythms of that type detected.

III. Single Rhythms.

1. *Nature of the Movement-Cycle of Any Rhythm.*

A movement may be perfectly regular, uniform, and recurrent and yet not give the impression of rhythm. If one moves the hand or arm in a circle, the hand may be made to pass a point in a circle much oftener per second that the tempo of the slower rhythms requires, and yet there will be no feeling of rhythm

[1] Squire, Mrs. C. R. (following Ettlinger), *Am. J. Psy.*, '00, 12, p. 541.
[2] Hallock, Miss M., *Pop. Sci. Monthly*, '03, 63, Sept., p. 425.
[3] MacDougal, R., *loc. cit.*
[4] Miner, *loc. cit.*, p. 33.
[5] Wallin, *loc. cit.*, p. 130.

so long as the hand moves uniformly and in a circle. In order to become rhythmic in the psychological sense, the following change in the movement is necessary: The path of the hand must be elongated to an ellipse; the velocity of the movement in a part of the orbit must be much faster than in the rest of the orbit; just as the hand comes to the end of the arc through which it passes with increased velocity, there is a feeling of tension, of muscular strain; at this point the movement is retarded, almost stopped; then the hand goes on more slowly until it reaches the arc of increased velocity. The rapid movement through the arc of velocity and the sudden feeling of strain and retarding at the end of this rapid movement constitute the beat. In consciousness they represent one event, and a series of such events connected in such a movement-cycle may be said provisionally to constitute a rhythm. Every rhythmic beat is a *blow*. The origin of rhythm, as Bücher has suggested, was in forms of concerted work which required blow on blow. That is possibly the genetic reason why the beat, the blow, is the primary thing in the rhythm-consciousness. In all forms of activity where a rhythm is required, the stroke, the blow, the impact, is the thing; all the rest is but connection and preparation. The movement in striking a quick blow or in beating a rhythm may be represented by *A* and *B* in the movement curve of Fig. 5 in which *A* represents the lifting of the member and *B* the rapid blow.

There is, then, a radical difference between the two phases of the rhythm-movement. The first great difference lies in the velocity of the two parts of the movement. In *B* of Table I., are given the velocities of the two phases of the movement in the case of three subjects beating rhythms as rapidly as possible. The velocity of the beat stroke is always two or three times greater than the velocity of the back-stroke, and the total relaxion-phase is always at least three times as long as the contraction-phase. A second difference between the two phases lies in the control which the subject has over the moving member; once the beat stroke is started, like a released spring the limb flies to the end of the stroke, and is in no wise subject to regulation; during the back-stroke on the over hand, the movement

TABLE I.

VELOCITY OF THE DOWN-STROKE AND OF THE UP-STROKE.

A. Velocity of the Down-stroke in very slow movements. Movement of the foot as slow as possible.

Subject.	Number Movements Measured.	Length of Down-stroke mm.	Time, σ.	Velocity, mm. per Second.	Metronome Tempo.
Sn.		15	87	172	c. 40 M.
		15	65	232.5	
		13	58	224	
		34	48.5	702	c. 20 M.
		30	93	410	
		35	68	516	Note that the stroke in the last three is longer, but time about the same.
Su.	13	28–16	64.6– 96.9	261–347	c. 120 M.: as fast as possible (for comparison).
Bg.	6	32–34.5	144 –161.5	196–231	c. 25 M.
Ha.	4	30–31	64 – 64.6	465–478	c. 20 M.
Ta.	11	6.6–10	35.5– 61	145–853	c. 54 M. Note that variation in Ta. records is due rather to length of stroke than to time of stroke.

B. Velocity of the down-stroke and up-stroke. Free movement of the hand and arm, as fast as possible.

Subject.	Number Movements Measured.	[1] Average Length Down-stroke.	Average Time of Down-stroke, σ.	[1] Average Rate Down-stroke.	[1] Average Length Up-stroke.	Average Time Up-stroke, σ.	[1] Average Rate Up-stroke.	Metronome Tempo.
Th.	1	81	113	742	81	158	516	c. 210 M.
	1	63	80.7	807	55	139	419.6	
	1	72	97	774	74	158	484	
	1	70	103	720	77	177.5	452	
	1	72	96.8	774	54	145	387.5	
	1	48	96.8	516	53	171	323	
	6	67.6	96.8	730	66	161.5	436	
	9	75	78.8	1033	74.3	184	426	c. 210 M.
St.	4	46	84	595	46	129	390	c. 240 M.
	4	51	80.7	646	49	126	390	
Bi.	14	42.6	48.8	952	43	138.7	336	c. 260 M.

[1] The lengths tabulated and therefore the rates are functions of the actual lengths. The actual stroke was about five times the recorded values.

In these very rapid movements the time of the up-stroke is much longer than the time of the down-stroke, and between the end of the up-stroke and the beginning of the down-stroke there is always a curve not here recorded, equal in duration to the down-stroke, so that *the total duration of the 'relaxation phase is at least three times the duration of the 'contraction phase.'*

may be regulated or changed at will. A third difference is noticed when two rhythms are beaten at the same time; the subordinate pulses of the one rhythm never occur during the beat-stroke of the other rhythm.

Nature of the Movement Beat-stroke. — However fast or slow the rhythmic movement, this high velocity is characteristic of the beat-stroke. In Table I., *A*, are given the duration values and the velocities of the beat-strokes in the slowest possible rhythms. It will be noted in the case of all four subjects that the duration of the beat-stroke is never more than 100 sig., and that the velocity is dependent on the length of the beat-stroke and not on the tempo of the rhythm. Under special limiting conditions the duration of the beat-stroke may be as long as 400 sig.,[1] but in all the records of freely-executed rhythms there are no beat strokes longer than 125 sig. and the velocity of the beat-stroke for the range of lengths which rhythmic movements present seems to be independent of the length of stroke. It is probable that if the movements were to be greatly exaggerated, differences of duration would appear; rapid movements of the eye show that the duration of the movement is affected by its length, though it does not vary directly. The duration of the beat-stroke is strikingly uniform, and is independent of either the tempo of the rhythm or the length of stroke. The clearest discussion of the events in such a rapid stroke brought to a sudden stop by the musculature, or by an obstacle, or by both, is found in Richer's discussion of human locomotion.[2] Richer divides all movements into three classes:

1. The two muscles or sets of muscles (*i. e.*, the antagonists, as the flexors and extensors, which produce the movement) contract simultaneously. (Ordinary type of slow movement.)

[1] Cf. Table II.

[2] *Traité de Physique Biologique*, D'Arsonval et Autres, Paris, '01. I., 'Locomotion Humaine,' p. 156 et suite. Richer, P., 'Note sur la contraction du muscle quadriceps dans l'acte de donner un coup de pied,' *Soc. de Biol.*, '95, Mars. 23. Athanasius, M. I., gives graphic records of similar movements obtained by a direct process, *C. R. de l'Acad.*, '02, 134, p. 311.

2. The one contracts, the other is passive. (Very excep tional type.)

3. The one contracts while the other relaxes and lengthens.

The rapid stroke in question is a form of this third type. This particular form of light, rapid, and sometimes repeated blow, Richer calls '*ballistic*.' By the study of instantaneous photographs he has determined that at the beginning of the stroke the positive muscle-set (extensors in case of the fore-arm) are suddenly contracted, but that by the end of the first third or first half of the movement, *the contraction of the positive muscle-set has ceased*, the positive muscles relax, and the limb is carried past this point by inertia alone. If the blow is delivered in the air, the negative muscle-set (in case of fore-arm, the flexors) contracts and stops the stroke. In rapidly repeated strokes of this kind, the member is returned to the original position by a similar sudden contraction of the negative muscle-set, which relaxes in the middle of the blow, and the stroke is in turn checked by the positive muscle-set. Thus the limb is *thrown* back and forth, and caught in turn at the limits of its movement by the positive muscle-sets. Such a battledore-and-shuttlecock type of movement is very aptly termed 'ballistic.' Rieger has recently described the same type of movement,[1] under the name of 'movements with elastic rebound,' but his form of record does not permit him to observe the action of antagonistic muscles as clearly as has Richer, and his concept of 'elastic rebound' is a better description than explanation of the movement. Rieger is aware however, that the beat-stroke of such a movement and its back-stroke make but a single unity in consciouness, and he promises to apply the principle of such a movement to the concept of accent in a future discussion.[2] As for the mechanism of innervation in such movement, Richer has no suggestion. Sherrington suggested[3] that 'reciprocal innervation' was the result of a fundamental structure of the muscle apparatus in antagonistic muscle-sets, but as Du Bois Reymond[4] points out there is no such fundamental grouping of

[1] Rieger, C., 'Über Muskelzustande,' *Zschr. f. Psy. u. Phys. d. S. org.*, '03, 32, S. 384 ff.

[2] *Loc. cit.*, S. 389.

[3] *Proceedings Royal. Soc.*, '97, p. 415.

[4] Du Bois Reymond, R., *Specielle Muskelphysiologie*, Berlin, '03, S. 243.

muscles into permanent antagonistic sets as the theory would require. Each set may be now antagonistic now synergic, and the rôle of muscles in the varied movements in which they take part is far too complex to admit of any fundamental neurological law of 'reciprocal innervation.' That such a reciprocal innervation does take place in the ballistic movement is evident, but it must be a type of coördination dependent on higher centers, and capable of all sorts of rearrangement, like other forms of complex muscular action and movement. What furnishes the precise signal for the action of the negative muscles in catching the limb tossed to them by the positive set? The case is different from that of an ordinary slow movement, where both sets of muscles are contracted, and the various inflowing kinæsthetic sensations check and guide the contractions of the muscles involved. The movement is very rapid; during the stroke the sensations are extremely vague, and as the experiments discussed later will show, frequently mislocated both in time and space. It does not seem possible that any event *after* the sudden contraction and relaxation of the positive muscle-set can be the cue for the contraction of the negative muscle-set. It is probable that the cue which sets the negative set to contracting is the *contraction of the positive muscle-set itself.* The brief interval between the positive contraction and the negative contraction, from 30 to 120 sig., is no more than time for a nervous impluse to be generated and reach the negative muscle-set.[1] The fact that time of the beat-stroke does not vary with the length of the beat-stroke, nor with the tempo of the rhythm favors this automatic connection of positive and negative muscles in the ballistic movement. It is experience alone which teaches us to guide the ballistic stroke. This experience is summed up in images of the movement (visual and 'motor'), which gauge the intensity of the positive muscle-set, and the appropriate contraction of the negative muscle-set follows inevitably.

An obstacle against which the limb strikes does not affect the character of the movement; at the end of the normal interval the negative muscle-set contracts and withdraws the limb, as

[1] Cf. Hofbauer, L., *Arch. f. d. ges. Physiol.* (*Pflüger's*), '97, 68, S. 553.

if the limb had shot to the end of its course unimpeded. It is simply as if the lower part of the oscillation had been cut off by the obstacle, and its place taken by a pause at the obstacle. If one closes the eyes and beats a rapid rhythm with the arm and hand, at first in the air, and then approaches an obstacle whose position is not exactly known until the hand strikes the obstacle

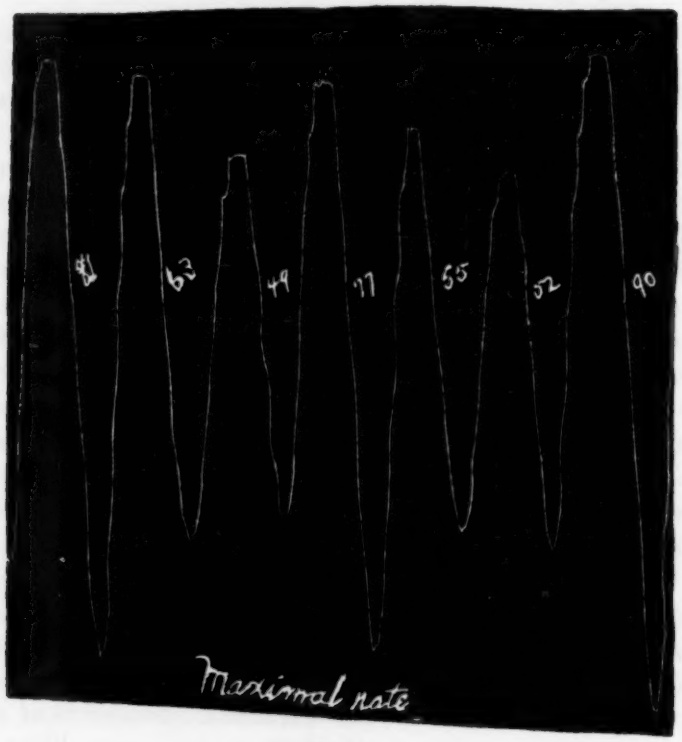

FIG. 1.

at each beat, one will find that the character of the movement and of the rhythm is quite unchanged by the intervention of the obstacle.

Nature of the Movement in the Back-stroke. — The relaxation-phase is not as invariable as the contraction-phase. In rapid beating the back-stroke begins immediately on the close of the beat-stroke; the record of such a rhythm beaten in the air shows a sharp angle between the beat- and back-stroke.

But, however rapid the rhythm, the velocity of the back-stroke is always much less (*cf.* Table I.), and at the end of the back-stroke, at the upper limit of the movement, there always appears a rounded curve which is very different from the sharp point at the lower limit.

In such rapid movement it is possible that the limb is driven back by a contraction of the negative muscle-set without any action of the positive-set. If so, the positive muscle-set must come gradually into action during the upper part of the back-stroke, for the rounded part of the curve at the upper limit of the most rapid movements can only mean that both sets are contracted, moving the limb slowly or holding it at rest just before the beat-stroke. During a slow rhythmic movement the limb often remains at the lower limit for some time, as if the negative contraction just balanced the momentum of the limb or the residual contraction of the positive muscle-set. In movements with great force at slow rates, it is certain that the positive-muscles are brought into play at the bottom of the beat-stroke, and coöperate with the negative muscle-set during the earlier part of the relaxation period in holding the limb. After this condition of rest at or near the lower limit of the movement for a longer or shorter interval, a very slow rise takes place (this may be modified in combined rhythms, as may be noted later) and the slow round of the curve at the upper limit shows that the two sets of muscles balance each other for a perceptible time just below the beat-stroke.

Although the phenomena of the relaxation-phase are thus somewhat variable, the relaxation-phase is a perfectly definite and essential process. The form of the rhythmic movement may be changed so that the limb does not return during the relaxation-phase to the upper limit for the next beat-stroke, but instead, the next beat-stroke starts from the point where the last beat-stroke ended. Measurements of records of such movements are given in Table II. The subject was directed to beat up and down with a baton, but to make a beat both on the down-stroke and on the up-stroke. The result is that every other beat-stroke occurs in the opposite direction from the intervening beat-stroke, and there is no back-stroke. What of the

process which the back-stroke represents in a rhythm-movement? On examining the records one sees that there is a long interval between the beat-strokes and during this interval the limb is at rest. (The pause is represented by a straight line on the moving kymograph cylinder.) (*Cf.* Fig. 2.)

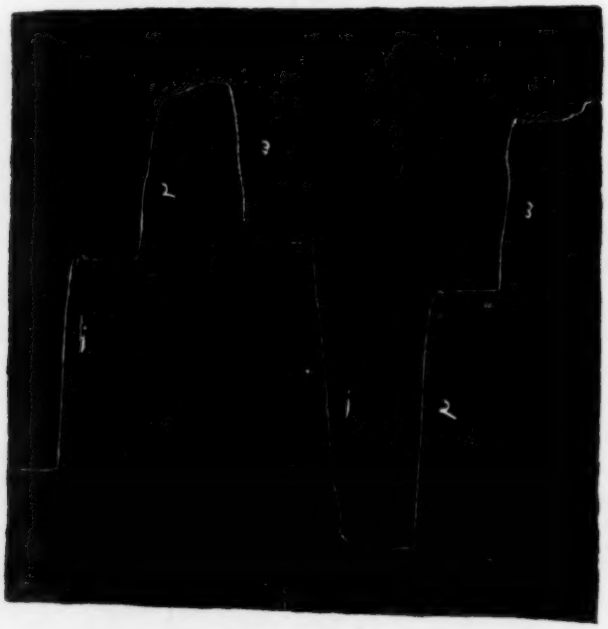

FIG. 2.

The duration of this pause appears from the measurements much longer than the beat-stroke, averaging from two to three times the duration of the beat-stroke. (*Cf.* Table II.)

The records of the three subjects were taken at medium and fairly rapid tempos, but the tempo does not affect the relative length of the pauses. After the experiments were performed on which Table II. is based, records of Rieger's were found which show the same relations at the fastest possible tempos. The records were taken for a different purpose, but the conditions are the same, and the movement was rhythmical.[1] At this maximal tempo, Rieger's figures show that at least

[1] *Loc. cit.*, S. 388.

TABLE II.

Comparison of the durations of the 'relaxation'- and 'contraction'-phases of a series of movements in which there is a beat both on down-stroke and up-stroke; these both become 'contraction'-phases and the pauses between them are the relaxation-phases.

Subject.	Number Movements Recorded.	Down-beat, σ.	Pause, σ.	Up-beat, σ.	Pause, σ.	Metronome Tempo.
Th.	1	355	387.5	193.5	452	70 M.
	1	355	387.5	226	355	
	1	355	484	193.5	387.5	
	1	323	484	226	484	
	1	291	452	226	387.5	
	1	387.5	613	161.5	419.5	
	1	355	419.5	226	484	
	1	226	419.5	291	323	
	1	387	452	226	452	
	1	355	355	226	484	
St.	12	Av. 317.5	Av. 312	Av. 196.5	Av. 201.6	82 M. Very little variation in values.
Bi.	12	297	490	193.6	323	76 M. Very little variation in values.
Th.	8	291	492.5	121	489	78 M. Very little variation in values.

Comparison of the durations of the 'relaxation'- and 'contraction'-phases of a series of movements in which there is a down-beat, then a second down-beat, then an up-beat, then a second up-beat, etc. (*cf.* **cut 2**).

Subject.	Number Movements Recorded.	Down-beat, σ.	Pause, σ.	Down-beat, σ.	Pause, σ.	Up-beat, σ.	Pause, σ.	Up-beat, σ.	Pause, σ.	Metronome Tempo.
St.										
	1	64.6	291	111.3	226	129	258	129	291	175 M.
	1	48.4	291	80.7	307	161.4	258	96.8	387.5	
	1	32.3	291	129	258	129	291	96.8	323	
	1	96.8	291	96.8	387.5	113	387.5	96.8	307	
	1	32.3	339	80.7	323	64.6	339	129	323	
	1	64.6	355	113	258	96.8	355	113	339	
	6	Av. 48.4	310	100	294	120	310	120	325	
Th.										
	6	80.6	310	122.7	184	100	310	84	339	140 M.
Bi.	6	113	403.7	132.4	397	119.5	452	122.7	384	120 M.
	6	190.6	336	119	355	132.4	387.6	193.8	355	155 M.

three fourths of the time was consumed in the relaxation-phase of the rhythm-movement. It is apparent that some preparatory process is necessary after one beat-stroke, before another beat-stroke can be made. Rieger's figures go to prove that this preparatory process takes more time when performed with the limb at a standstill, than when the limb is in motion as in the usual back-stroke.

This preparatory process must consist of a change in muscular tensions, since the limb is practically at rest. At the end of the beat-stroke, the negative muscle-set contracts sharply; in rapid beating at least, there is also a contraction at this point, or a residual tension, in the positive muscle-set. Except possibly in very slow beating, the contraction of the negative muscle-set cannot be so proportioned as to just balance the momentum of the limb, and tension in the positive muscle-set is necessary if the limb is to come to a standstill at the close of the beat-stroke. During the long pause which takes the place of the ordinary back-stroke the contraction of the negative muscle-set gives way to relaxation and the tension in the positive muscle-set becomes very slight. This is the poised condition just before the second beat-stroke.

The relaxation-phase alone is subject to control. Changes in tempo are due to voluntary hastening or retarding during the relaxation process. This fact is of considerable importance in conducting. A chorus or orchestra depend quite as much on the back-stroke as they do on the beat-stroke for direction. Conducting at the organ or piano is always unsatisfactory, and an angular style of beating which suppresses the back-stroke is almost as ineffective.

The events, then, in any rhythmic movement-cycle producing the simplest possible series of beats is as follows: At the beginning of the beat-stroke there is a sharp contraction of the positive muscle-set, setting the limb into rapid motion, during the earlier part or the first half of which the contraction of the positive muscle-set gives way to relaxation; this contraction-relaxation process in the positive muscle-set is the cue for the automatic contraction of the negative muscle-set; at the end of the flight of the limb, the negative muscle-set contracts sud-

denly and automatically and arrests the limb; this contraction of the negative muscle-set works against the momentum of the limb and a possible residual or active tension of the positive muscle-set; this ends the contraction-phase. After the contraction of the negative muscle-set has overcome the resistance at the bottom of the stroke, the contraction grows rapidly less, any tension between the two muscle-sets is reduced, and the condition of a very slight tension between the two muscle-sets, with the limb poised, is reinstated; this is the condition at the beginning of the beat-stroke (in the normal movement-cycle, the limb is raised at a varying velocity to its original position during the readjustment of the relaxation-phase) and the close of the relaxation-phase.

This movement-cycle is usually given its form and limits by a rather definite image of the movement. The upper limit with many subjects does not seem to be reached by a uniform movement through a certain time or during a certain definite change of tensions, for these subjects raise the limb at varying points in the cycle to the proper height and leave it at rest, awaiting the beat-stroke. But in itself this image of the movement would not give rise to any feeling of *movement*, or any impression of rhythm.

In the case of a rhythm beaten against a heavy resistance the figure previously published[1] is probably an approximate representation of the movement, but for the normal, freely beaten rhythm, the writer now considers the accompanying Fig. 5 a more accurate representation of the process (*cf.* Fig. 5).

Temporal Relations which Depend on Mere Accent. — Aside from the temporal relations of the typical unit-groups to be considered later, there are certain temporal relations which are to be referred directly to the nature of the movement-cycle of the single beat. The well-known lengthening of the accented beat, and the 'pause' which precedes the accented beat are due to modifications of the cycle. There are two ways in which the increased force of an accented beat may be obtained; either the length of the stroke may be increased (just as the upright-piano action is arranged to give degrees of loud and soft

[1] 'Rhythm and Rhyme,' *Harvard Psy. Stud.*, I, p. 454.

by varying the length of the hammer-stroke), or the path of the limb may be unchanged and the contraction of the positive muscle-set more powerful. As greater length is usually associated with intenser contraction, probably both occur in untrammeled beating. Either of these ways will slightly modify the temporal relations of the resulting beats.

Although the time of the beat-stroke is little changed if the stroke is lengthened, the limb must be raised higher than usual, and this must add to the interval preceding. If there were any increase of the duration of the beat-stroke, that would be added to the preceding interval, for the ordinary methods of measurement make the end of the beat-stroke, or the limiting sensation the point of departure.

If the limb, in beating rhythmically, does not impinge on an obstacle, the accented beat will descend lower than the average beat, because its greater momentum will carry it farther. It will take more time for the relaxation process following the heavy beat, for higher strains must be reduced to the poised condition, and in untrammeled beating the limb must be raised through a longer back-stroke to the usual upper limit of the movement. As noted above (Fig. 1), an obstacle against which the limb strikes does not change the character of the movement; the action of the muscles is the same as if the limb had shot down to the end of the interrupted stroke. But it is customary to measure the beat from the point where the limb first touches the obstacle, so that a rhythm in which the accent is determined largely by increased contraction with the limb striking an obstacle will show by the ordinary method of measurement a decided increase in the length of the interval following the accented beat. The accented movement must always take more time however the increase is distributed before and after the beat by the particular method of measurement chosen.